B
22, 11-16

LIBRARY
FISH & WILDLIFE SERVICE
PACIFIC OCEANIC FISHERY
INVESTIGATIONS

UNIVERSITY OF TORONTO STUDIES

BIOLOGICAL SERIES

No. 22: PUBLICATIONS OF THE ONTARIO FISHERIES RESEARCH LABORATORY, XI-XVI

11-16

THE UNIVERSITY LIBRARY: PUBLISHED BY THE LIBRARIAN, 1923

University of Toronto Studies

COMMITTEE OF MANAGEMENT

Chairman: Sir Robert Alexander Falconer, LL.D., K.C.M.G.,
President of the University

Professor W. J. Alexander, Ph.D.

Professor J. P. McMurrich, Ph.D.

Brig.-Gen. C. H. Mitchell, B.A.Sc., C.B., C.M.G , D.S.O.

Professor G. H. Needler, Ph.D.

Professor George M. Wrong, LL.D.

General Editor: W. S. Wallace, M.A.,
Associate Librarian of the University

UNIVERSITY OF TORONTO STUDIES

PUBLICATIONS OF THE
ONTARIO FISHERIES RESEARCH LABORATORY
No. 11

THE LIMNOLOGY OF LAKE NIPIGON

BY

WILBERT A. CLEMENS

OF THE DEPARTMENT OF BIOLOGY

UNIVERSITY OF TORONTO

TORONTO
THE UNIVERSITY LIBRARY
1923

THE LIMNOLOGY OF LAKE NIPIGON

During the months of June, July and August, 1921, an intensive limnobiological investigation of Lake Nipigon was commenced by a field party from the Ontario Fisheries Research Laboratory, of the Department of Biology, University of Toronto, under the direction of the writer. The purpose of the investigation was to carry out a thorough study of the biological and environmental factors, with special reference to the fish fauna and its economic and conservational aspects. Lake Nipigon was selected for investigation because of its isolation for a long period of time from the Great Lakes and, as far as known, from any other drainage system. As a result, natural conditions have been undisturbed either in the drainage basin or in the lake itself, except by reason of the opening of the lake to restricted commercial fishing in recent years. In 1916, the Department of Game and Fisheries of the Province of Ontario opened the lake under supervision to commercial fishing for the purpose of augmenting the food supply during the war, and have continued the policy with some modifications to the present time. Statistics are available for only four years, 1916-1919, but during that time the following amounts of fish were removed: whitefish 2,511,614 lbs., lake trout 1,059,632 lbs., pike perch 51,431 lbs., sturgeon 21,810 lbs., other species, chiefly pike, ciscoes and northern suckers, 57,694 lbs. In 1920, the following plants were made: whitefish 8,943,000 fry, lake trout 734,000 fry, and 240 parent black bass. It seemed desirable therefore to determine the conditions existing in a lake before the effects of such disturbances of natural conditions had become pronounced. An opportunity was thus afforded of studying the effects of commercial fishing in a circumscribed body of water and of

developing working plans for the best utilization of the productive possibilities of such a body.

In view of the above considerations, the investigation during the first season followed three main lines:—

(1) the identification of the species of fish, their distribution, relative abundance, natural history, food and rates of growth;

(2) qualitative and quantitative studies of the food organisms, confined largely to the plankton and the bottom fauna;

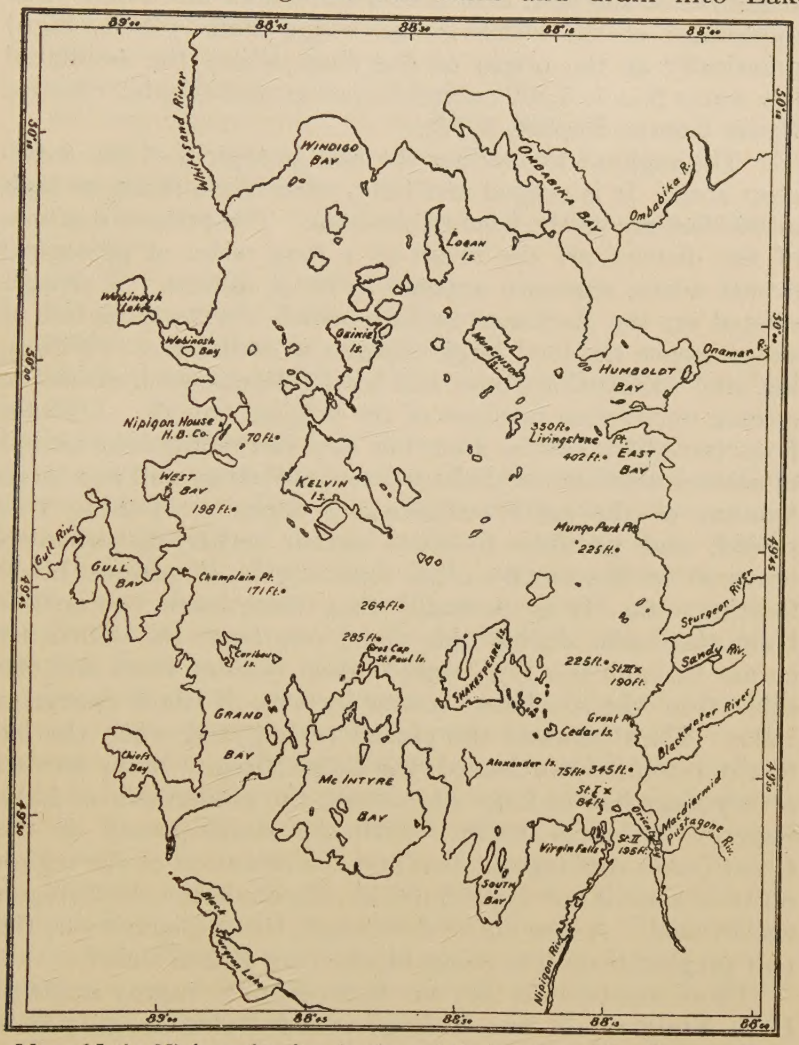
(3) a study of the physical features, particularly temperatures, dissolved oxygen and carbon dioxide, colour and transparency, and the significance of these factors in respect of the biology of the lake.

Some of the results obtained are presented in more or less preliminary form in this and the following five papers.

Lake Nipigon, the largest of the many inland bodies of water in Ontario, is situated in the northwestern portion of the province about 50 miles north of Lake Superior. It lies approximately between 87°35′ and 89°10′ west longitude and between 49°5′ and 50°30′ north latitude. The area as given by Wilson (1910) is 1769 square miles, of which about 1530 square miles is water surface, leaving an island area of about 239 square miles. The lake is roughly quadrangular in form, about 50 miles long and 30 miles wide, but very irregular in outline with numerous bays of various sizes and contours. The shore line is characterized by rocky projections and headlands alternating with indentations. The latter, when open and exposed, are rocky or sandy, but where extended and protected, tend to become muddy with an approach to marshy conditions. The length of the coast line exclusive of smaller bays and coves is over 580 miles (Bell, 1870). The islands are numerous, particularly in the northwestern portion, and range in size from small rocky projections to large wooded areas. The elevation of the water surface is 852 feet above sea level (White, 1915).

The drainage basin comprising about 6,000 sq. mi. is fairly well covered with tree growth consisting chiefly of balsam, spruce, poplar and birch, with a scattering of red pine, jack-

pine, tamarack, cedar and alder, and the major portion is included in the Nipigon Forest Reserve. Numerous catchment basins, ranging in size from small ponds to large lakes, are scattered throughout the basin and drain into Lake



Map of Lake Nipigon showing depths and the location of the three stations for the taking of plankton, temperatures and water samples.

Nipigon by a large number of streams. There is, on the other hand, but one outlet, the Nipigon River, by which the drainage is carried southward into Lake Superior, through a descent of 250 feet, over a series of rapids and falls. The uppermost of the latter is the Virgin Falls (35 ft. high) practically at the origin of the river, where the estimated low water flow is 5.500 cubic feet per second (Hydro Electric Power Comm. Report, 1907).

The region surrounding the lake is typical of the Archaean area. It is rugged and hilly, with bluffs rising as high as 600 feet above the level of the lake. The present features of the district are the result of a long series of geological events whose sequence appears to be as follows. A trough existed on the Archaean surface which during a period of submergence received large deposits of sediments. (Wilson, loc. cit.) Elevation above sea level followed with extensive erosion uncovering portions of the original trough. Diabase flows later invaded the area, but in a succeeding long period of erosion much of the diabase was removed as well as a large amount of the early sedimentary deposits. During this period, and possibly to some extent earlier, disturbances occurred in the earth's crust resulting in elevations, block faulting, etc. It is probable that there were two outlets from the basin during this time, one from the southeast corner through the Pijitawabic canon (Orient Bay) and the other from the southwest corner by way of Black Sturgeon Lake. Then followed the glacial period, and when the ice finally retreated northward, the Lake Nipigon basin formed a very large bay of Lake Algonquin, the predecessor of Lake Superior (Coleman, 1922). With the development of the Great Lakes drainage system and the elevation of the region north of what is now Lake Superior, the modern Lake Nipigon was formed. A new outlet developed, the Nipigon river, the two preglacial outlets being blocked by glacial debris.

There has been as yet no hydrographic survey made of Lake Nipigon. A line of large islands lying roughly in a north to south direction divides the lake more or less into east and west portions. The eastern portion contains the

deeper water which lies well over towards the eastern shore. Soundings taken in the course of dredging and limnological operations gave the following depths:—

195 feet Pijitawabic Bay, opposite Macdiarmid village.

345 feet off mouth Blackwater river.

225 feet off mouth Sandy river.

225 feet off Mungo Park Point.

402 feet was recorded by McInnes (1894) two and a half miles south of Livingstone Point. This is probably the greatest depth in the lake.

In the western portion the following records were obtained:—

198 feet west of Kelvin island.

171 feet east of Champlain Point.

264 feet northeast of Grand Cape.

285 feet was recorded by McInnes just north of St. Paul island.

It is thus evident that there is a very large body of deep water in Lake Nipigon and that the amount of shallow water is limited. The open shores are rocky or sandy and because of the size of the lake, subject to strong wave action. It is only in the deep, protected bays and shallow areas among the islands where conditions are such as to permit the growth of the larger aquatic vegetation with the accompanying abundance of animal life.

Because of the great extent of Lake Nipigon, the first season's investigations were confined largely to the southeastern portion. Three stations were established for the taking of temperature records, water samples and plankton. Station 1 was located in comparatively shallow water (depth of 28 yards) off the mouth of the Nipigon river; station 2 in the deepest water (depth of 63 yards) of Pijitawabik bay (Orient Bay) directly opposite the village of Macdiarmid; station 3 in the open water off Sandy river (depth of 63 yards). One series was obtained on August 29 off the mouth of the Blackwater river (depth of 100 yards).

The temperature records were obtained with a standardized Negretti-Zambra deep-sea reversing thermometer. Water

samples were taken immediately after the temperature records with a modified Kemmerer water bottle (Birge, 1922). The water samples were put in 250cc. glass-stoppered bottles, packed in broken ice and taken to the laboratory where the analyses were carried out. The oxygen content was determined by a modification of Miller's method (Provincial Board of Health of Ontario, 1920). For the carbon dioxide determinations N/22 sodium carbonate with phenolphthalein as indicator was used (Prov. Board of Health, loc. cit.).* The temperature records and the results of the analyses are given in Tables 1, 2 and 3, and from this data Figs. 1 to 6 have been constructed.

Since no record of the temperature of the deepest water was obtained in this season it has been assumed, on the basis of the results obtained at the three stations, that the temperature was 4.0°C. Fig. 3 may be taken as a fairly accurate record of events. From June 17 to July 9 the surface waters were gradually acquiring heat and the thermocline was slowly increasing in thickness (Table 4). No record for late July was obtained for Station 3, but judging from the record for Station 2 on July 26, by the end of July the epilimnion had doubled in thickness and the thermocline therefore had shifted downward.

During the morning of July 30 a wind of considerable violence came up accompanied by some rainfall. The wind blew first from the southwest and gradually shifted to northwest reaching its maximum velocity about 2 p.m. No meteorological records are available for the Nipigon region, but judging from records obtained at various stations in Northern Ontario, it is probable that the wind attained a velocity at times of about 35 miles an hour. Captains on the fishing tugs stated that this was the worst mid-summer storm they had experienced on this lake. The temperature records on August 2 show the effects of the storm. The thermocline in the open part of the lake was obliterated. Apparently the three strata were set in motion and some of

*All the solutions were prepared by Mr. George W. Lucas of the Department of Chemistry, University of Toronto, and the Provincial Board of Health.

TABLE 1

STATION 1

Depth in yards	June 13				July 23				August 18			
	Temp. C.	Ox.	% Sat.	CO_2	Temp. C.	Ox.	% Sat.	CO_2	Temp. C.	Ox.	% Sat.	CO_2
Surface	8.3	7.8	94		19.4	5.8	87	1.4	16.2	6.2	88	1.7
1	7.1			1.7	19.4							
2	6.8				19.2							
3	6.7											
5					19.2	5.8	87	0.6	16.0			
6	6.4	7.8	89	1.6								
9	5.8											
10					18.7	6.0	89	0.9	15.9			
11	5.8	8.0	90	1.1								
13	5.7				14.2							
15					11.5	7.4	95	1.0	15.8	6.4	90	1.1
16	5.6	7.8	88	1.1								
20					6.7	7.7	89	1.1	11.3	6.7	86	2.0
21	5.5	7.9	88									
25									7.0			
26	5.4	8.0	89	0.0								
28					4.8	7.7	85	1.4	6.5	7.1	82	2.2

TABLE 2

STATION 2

Depth in yards	June 14				June 28				July 8			
	Temp. C.	Ox.	% Sat.	CO_2	Temp. C.	Ox.	% Sat.	CO_2	Temp. C.	Ox.	% Sat.	CO_2
Surface	9.4.	7.7	95	none	17.4	6.2	90	1.1	20.2	6.55	100	0.9
1					15.5							
2					12.9							
3												
4					12.4							
5	8.2	8.0	96		12.4	6.9	91	0.6	11.4	7.00	90	0.9
8									9.3	7.65	94	1.1
10	7.1	7.9	92		10.4	6.9	87	0.6	7.2			
15	6.8				9.0	7.8	95	0.8	6.4	7.70	88	1.1
20	6.5	8.1	93		7.2	7.8	91	1.1	5.8			
25	5.4	8.3	93		6.4				5.4	7.85	88	1.1
30	5.1				5.6	7.7	87	1.1				
35									4.8			
40	4.9				5.1	7.8	87	1.1				
45	4.8								4.5			
50		8.0	88		4.6	7.9	87	1.1				
55									4.3			
60										7.80	85	1.1
63					4.0	8.0	86	0.8				
65									4.2			

TABLE 2 (*continued*)

STATION 2

Depth in yards	July 26				August 1				August 17			
	Temp. C.	Ox.	% Sat.	CO_2	Temp. C.	Ox.	% Sat.	CO_2	Temp. C.	Ox.	% Sat.	CO_2
Surface	20.1	5.80	89	1.4	17.7	5.90	86	0.9	17.2	6.00	87	1.4
1												
2												
3									16.1			
4												
5	19.9	5.75	87	0.9	17.7				15.7			
8	19.1	6.00	90	1.1								
10	12.9				17.6				15.4			
15	8.0	6.05	72	1.1	17.2	5.95	86	1.1	15.0	6.15	85	1.4
20	6.8				10.3	7.00	88	1.1	11.0	6.50	83	1.7
25	6.0				8.6	7.40	90	1.7	7.4	6.85	75	1.1
30	5.6	7.75	87	1.7	7.6				6.4			
35												
40	5.0				6.3	7.50	89	1.7	5.8			
45												
50	4.8				5.6				5.6			
55	4.6	7.85	86	1.9								
60									5.4	7.15	80	1.7
63					4.8	7.60	84	2.2				
65												

TABLE 3

STATION 3

Depth in yards	June 17	June 23				July 9				August 2			
	Temp. C.	Temp. C.	Ox.	% Sat.	CO_2	Temp.C.	Ox.	% Sat.	CO_2	Temp.C.	Ox.	% Sat.	CO_2
Surface	12.5	14.9	7.7	106	1.4	22.0	6.3	99	1.2	16.2	6.3	89	1.1
5	8.5	13.4	7.8	104	1.1	16.6	6.4	91	1.1	15.9			
8						11.3							
10	7.7	8.2	7.9	94	1.7	9.3	7.3	90	1.1	15.8	6.4	90	1.1
15	7.4	7.1				6.7				15.0			
18													
20	6.0	5.8	7.9	89	1.1	6.2	7.6	87	1.7	13.0	6.6	88	1.1
25	5.2	5.2								11.8	6.9	90	1.1
30	5.0		8.0	88	1.7	4.9	7.6	84	1.4	8.8	7.0	85	1.1
40	4.8		7.9	87	1.7	4.3				6.5			
45						4.2	7.7	84	1.4				
50										5.1			
53	4.0												
60													
63										4.6	7.65	84	2.2
80													
90													
100													

STATION 3 (*continued*)

Depth in yards	August 29†			
	Temp. C.	Ox.	% Sat.	CO_2
Surface	17.1	6.05	87	1.1
5	16.8			
8				
10	15.9			
15	15.2	7.00	97	1.1
18	9.0			
20	8.0	6.25	74	1.1
25	6.7			
30	6.3			
40	5.7			
45				
50				
53				
60	5.2			
63				
80	4.9			
90	4.5	6.40	70	1.6
100	4.2	5.70	62	2.2

†Off mouth Blackwater river.

TABLE 4

STATION 2

	July 8, 1921		July 26		August 1		August 17	
	Depth m.	Temp. C.	Depth m.	Temp. C.	Depth m.	Temp. C.	Depth m.	Temp. C.
Epilimnion	0.0- 1.0	20.2-19.9	0-5	20.5-19.5	0-11	17.7-17.1	0-12	17.2-14.0
Thermocline	1.0- 7.0	19.9- 7.2	5-10	19.5- 8.5	11-14	17.1-10.6	12-17	14.0- 8.2
Hypolimnion	7.0-60.0	7.2- 4.2	10-60	8.5- 4.4	14-60	10.6- 4.8	17-60	8.2- 5.3

STATION 3

	June 17		July 9		August 2		August 29	
	Depth m.	Temp. C.	Depth m.	Temp. C.			Depth m.	Temp. C.
Epilimnion	0-3	12.5-11.0	0-2	22-21			0-14	17.1-15.0
Thermocline	3-4	11.0- 9.0	2-8	21-10			14-16	15.0- 9.5
Hypolimnion	4-123.4	9.0- 4.0	8-123.4	10-4			16-123.4	9.5- 4.0

the warm surface waters were carried almost to the bottom of the lake. At Station 2 in the sheltered bay (Fig. 2) the thermocline was not obliterated but was decreased in thickness and pushed downward several metres. We have here a good example of the effect of the wind in distributing heat in a lake. Later on in August typical stratification was again established as shown by the record for August 29.

The records in Figs. 1 and 2 coincide in general with that in Fig. 3 to depths of 30 and 60 metres respectively.

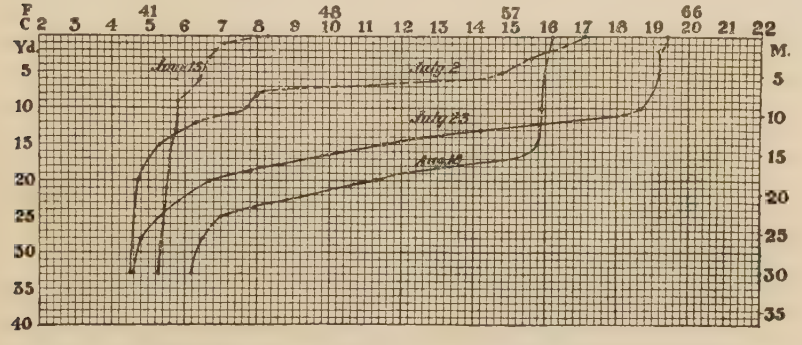


FIG. 1. Curves illustrating temperature records at Station 1, Lake Nipigon.

DISTRIBUTION OF HEAT.

In the absence of an hydrographic survey of Lake Nipigon, it is impossible at the present time to calculate the summer heat income and the work involved in the distribution of the heat on the basis of mean temperature and reduced thickness. Calculations have been made, however, for a column of water one square centimetre in area extending from surface to bottom. These figures are of some interest in indicating the distribution of heat and work for those particular points in the lake but do not furnish very accurate data which may be compared with that calculated for other lakes on the basis of mean temperature and reduced thickness (Birge, 1916).

In Tables 5, 6 and 7 are given, (1) the temperatures at five-metre intervals as taken from Figs. 1, 2 and 3, and (2) the mean temperature for each five-metre stratum. The latter

figures have then been used for the calculation of the number of gram calories per square centimetre of surface received by each five-metre stratum above 4°C. using the formula $(T-4)\times 500$. These results are given in Tables 8, 9 and 10 and show:

(1) that by the middle of June about a third of the total amount of heat of the season had been gained and that this heat was contained in the upper half of the lake, that is, in the upper 60 metres;

(2) that by the end of the first week in July there had been a considerable gain in heat by the upper waters, confined largely to the upper five metres.

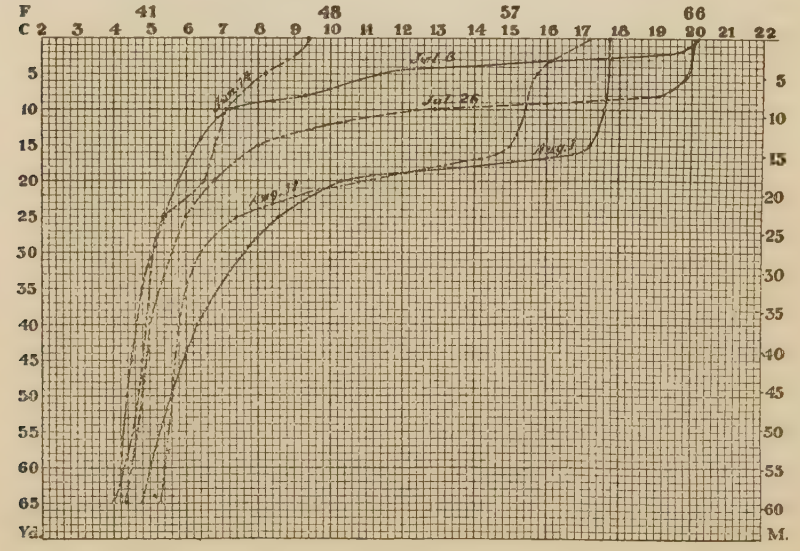


FIG. 2. Curves illustrating temperature records at Station 2, Lake Nipigon.

(3) that by the end of July there had been large gains in heat by the upper 20 metres. Unfortunately no temperature records were obtained in late July in the open waters, but it is doubtful if at the end of July any appreciable amount of heat had penetrated below 60 metres.

(4) that the effect of the storm on July 30 was to dis-

TABLE 5

TEMPERATURES—STATION 1

Depth m.	June 13		July 2		July 23		August 18	
	Temp. C.	Av. Temp. per 5-m. l.	Temp. C.	Av. Temp. per 5-m. l.	Temp. C.	Av. Temp. per 5-m. l.	Temp. C.	Av. Temp. per 5-m. l.
0	8.30		17.1		19.40		16.2	
5	6.45	7.37	14.5	15.80	19.15	19.27	15.95	16.07
10	5.80	6.12	7.4	10.95	18.35	18.75	15.9	15.92
15	5.60	5.70	5.1	6.25	10.00	14.17	15.7	15.80
20	5.50	5.55	4.65	4.87	6.1	8.05	9.5	12.60
25	5.40	5.45	4.55	4.60	4.9	5.50	6.6	8.05
30	5.30	5.35	4.50	4.52	4.6	4.75	6.2	6.40

TABLE 6

TEMPERATURES—STATION 2

	June 14		July 8		July 26		August 1		August 17	
Depth m.	Temp. C.	Av. Temp. per 5-m. l.	Temp. C.	Av. Temp. per 5-m. l.	Temp. C.	Av. Temp. per 5-m. l.	Temp. C.	Av. Temp. per 5-m. l.	Temp. C.	Av. Temp. per 5-m. l.
0	9.4		20.2		20.1		17.7		17.2	
5	8.0	8.70	11.0	15.6	19.9	20.00	17.7	17.70	15.65	16.42
10	7.05	7.52	7.0	9.0	11.4	15.65	17.55	17.62	15.35	15.50
15	6.7	6.87	6.1	6.55	7.6	9.50	16.40	16.97	14.40	14.87
20	6.15	6.42	5.6	5.85	6.45	7.02	9.55	12.97	9.2	11.80
25	5.2	5.67	5.2	5.4	5.80	6.12	8.1	8.82	6.9	8.05
30	5.05	5.12	4.9	5.05	5.40	5.60	7.2	7.6	6.15	6.52
35	4.95	5.00	4.7	4.8	5.15	5.27	6.6	6.9	5.9	6.02
40	4.85	4.90	4.5	4.6	4.95	5.05	6.0	6.3	5.7	5.80
45	4.7	4.77	4.4	4.45	4.80	4.87	5.6	5.8	5.6	5.65
50	4.55	4.62	4.3	4.35	4.65	4.72	5.3	5.45	5.5	5.55
55	4.30	4.42	4.2	4.25	4.50	4.57	5.0	5.15	5.4	5.45
60	4.0	4.15	4.2	4.20	4.30	4.40	4.75	4.87	5.3	5.35

TABLE 7

TEMPERATURES—STATION 3

	June 17		July 9		August 2		August 29	
Depth m.	Temp. C.	Av. Temp. per 5-m. l.	Temp. C.	Av. Temp. per 5-m. l.	Temp. C.	Av. Temp. per 5-m. l.	Temp. C.	Av. Temp. per 5-m. l.
0	12.5		22.0		16.2		17.1	
5	8.4	10.45	15.8	18.9	15.8	16.02	16.75	16.92
10	7.7	8.05	8.7	12.2	15.7	15.77	15.8	16.27
15	7.1	7.4	6.5	7.6	14.4	15.05	12.8	14.30
20	5.6	6.35	6.05	6.27	12.6	13.5	7.4	10.10
25	5.1	5.35	5.3	5.67	10.4	11.5	6.5	6.95
30	4.95	5.02	4.6	4.95	8.15	9.27	6.15	6.32
35	4.8	4.87	4.35	4.47	6.9	7.52	5.8	5.97
40	4.7	4.75	4.2	4.27	5.95	6.42	5.6	5.70
45	4.3	4.5	4.15	4.17	5.2	5.57	5.45	5.52
50	4.0	4.15	4.0	4.07	4.85	5.02	5.35	5.40
55	4.0	4.0	4.0	4.0	4.65	4.75	5.2	5.27
60	4.0	4.0	4.0	4.0	4.6	4.62	5.1	5.15
65	4.0	4.0	4.0	4.0	4.55	4.57	5.0	5.05
70	4.0	4.0	4.0	4.0	4.5	4.52	4.95	4.97
75	4.0	4.0	4.0	4.0	4.45	4.47	4.85	4.90
80	4.0	4.0	4.0	4.0	4.4	4.42	4.75	4.80
85	4.0	4.0	4.0	4.0	4.35	4.37	4.65	4.70
90	4.0	4.0	4.0	4.0	4.3	4.32	4.60	4.62
95	4.0	4.0	4.0	4.0	4.25	4.27	4.55	4.57
100	4.0	4.0	4.0	4.0	4.2	4.22	4.45	4.50
105	4.0	4.0	4.0	4.0	4.2	4.20	4.35	4.40
110	4.0	4.0	4.0	4.0	4.15	4.17	4.25	4.30
115	4.0	4.0	4.0	4.0	4.1	4.12	4.15	4.20
120	4.0	4.0	4.0	4.0	4.05	4.07	4.05	4.10
123.4	4.0	4.0	4.0	4.0	4.0	4.00	4.00	4.00

TABLE 8

CALORIES ABOVE 4° C.—STATION 1

Depth m.	June 13		July 2		July 23		August 18	
0-5	1685		5900		7635		6035	
5-10	1060		3475		7375		5960	
10-15	850		1125		5085		5900	
15-20	775		435		2025		4300	
20-25	725	5095	300	11235	750	22870	2025	24220
25-30	675	675	260	260	375	375	1200	1200
		5770		11495		23245		25420

TABLE 9

CALORIES ABOVE 4° C.—STATION 2

Depth m.	June 14		July 8		July 26		August 1		August 17	
0-5	2350		5800		8000		6850		6210	
5-10	1760		2500		5825		6810		5750	
10-15	1435		1275		2750		6485		5435	
15-20	1210		925		1510		4485		3900	
20-25	835	7590	700	11200	1069	19145	2410	27040	2025	23320
25-30	560		525		800		1800		1260	
30-35	500		400		635		1450		1010	
35-40	450		300		525		1150		900	
40-45	385		225		435		900		825	
45-50	310	2205	175	1625	360	2755	725	6025	775	4770
50-55	210		125		285		575		725	
55-60	75	285	100	225	200	485	435	1010	675	1400
		10080		13050		22385		34075		29490

TABLE 10

CALORIES ABOVE 4° C.—STATION 3

Depth m.	June 17		July 9		August 2		August 29	
0-5	3225		7450		6010		6460	
5-10	2025		4100		5885		6135	
10-15	1700		1800		5525		5150	
15-20	1175		1135		4750		3050	
20-25	675	8800	835	15320	3750	25920	1475	22270
25-30	510		475		2635		1160	
30-35	435		235		1760		985	
35-40	375		135		1210		850	
40-45	250		85		785		760	
45-50	75	1645	35	965	510	6900	700	4455
50-55					375		635	
55-60					310		575	
60-65					285		525	
65-70					260		485	
70-75					235	1465	450	2670
75-80					210		400	
80-85					185		350	
85-90					160		310	
90-95					135		285	
95-100					110	800	250	1595
100-105					100		200	
105-110					85		150	
110-115					60		100	
115-120					35		50	
120-123.4					0	280	0	500
		10445		16285		35365		31490

tribute heat practically to the bottom of the lake. The amount distributed to the deep water is relatively small, however, the great bulk being retained in the upper five metres.

(5) that by the middle of August the lake had begun to

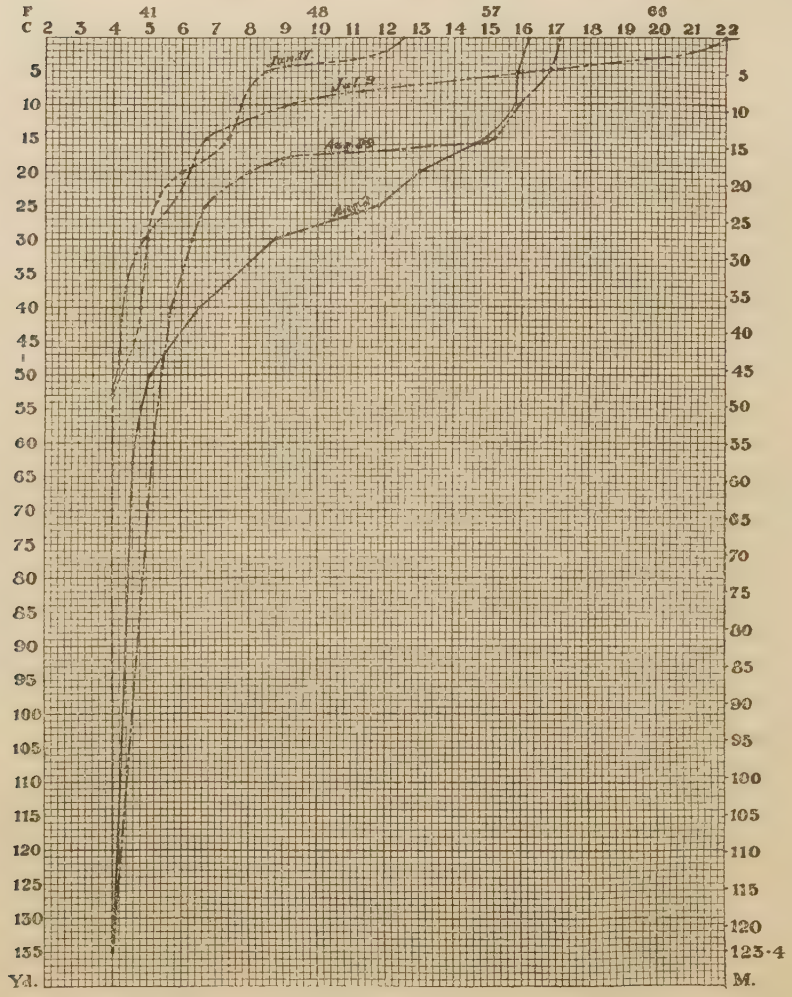


FIG. 3. Curves illustrating temperature records at Station 3, Lake Nipigon.

give up some of its heat. The loss in the upper 25 metres has probably been into the air, while the 25-50 metre area may have contributed of its heat to the underlying waters which apparently continued to gain heat for some days following the storm.

It is probable that the summer heat income for Lake Nipigon in 1921 was in the neighbourhood of 30,000 gram calories per sq. cm. of surface. The mean summer heat income for Cayuga Lake, N.Y., over a period of five years was 29,480 calories (Birge and Juday, 1921), with the maximum in one year of 30,910 calories. The two lakes have approximately the same maximum depth, Cayuga 133 metres, Nipigon 123.4 metres.

Distribution of Heat

The amount of work in gram-centimetres involved in the distribution of the heat contained in a column of water one square centimetre in area has been calculated for each metre stratum using the formula $(I-D)\times CG$, where $(I-D)$ is the loss of density due to warming, C, the depth in centimetres and G, the weight in grams. This is based on the principle stated by Birge (1916), that for the most part, the warming of the water in a lake is done by the transference of warm lighter water from the surface downward through water at its maximum density, by the agency of the wind. This involves an expenditure of work which can be calculated.

The results here given are for each five-metre stratum and the temperatures used in the calculations are the means of the five-metre strata as given in Tables 5, 6 and 7. Further accuracy in this instance did not seem warranted. The results are shown in Tables 11, 12 and 13. The significant points are:—

(1) that from the middle of June to the end of the first week in July practically all of the work was expended in the upper 10 metres and particularly in the upper five metres.

(2) that during July, the work was expended to a greater depth but especially in the 5-10 metre stratum.

TABLE 11

DIRECT WORK—STATION 1

Depth m.	June 13	July 2	July 23	August 18
0-5	13.50	150.00	243.75	156.75
5-10	14.00	144.00	608.00	406.00
10-15	14.95	26.00	490.75	650.00
15-20	18.00	5.40	112.50	490.50
20-25	19.55	3.45	20.70	143.75
25-30	21.00	2.80	7.00	63.00
	101.00 g. cm.	331.65 g. cm.	1482.70 g. cm.	1910.00 g. cm.

TABLE 12

DIRECT WORK—STATION 2

Depth m.	June 14	July 8	July 26	August 1	August 17
0-5	25.50	144.75	265.50	198.75	165.00
5-10	38.80	76.00	390.00	524.00	380.00
10-15	42.25	32.50	149.50	773.50	555.75
15-20	42.30	25.20	63.90	531.00	409.50
20-25	25.30	18.40	40.25	207.00	143.75
25-30	14.00	12.60	29.40	140.00	70.00
30-35	13.20	8.25	23.10	107.25	54.45
35-40	13.30	5.70	17.10	79.80	49.40
40-45	10.75	2.15	12.90	55.90	47.30
45-50	7.20	2.40	9.60	40.80	48.00
50-55	2.65	2.65	7.95	29.15	45.05
55-60	0	0	2.90	17.40	43.50
	235.25 g. cm.	330.60 g. cm.	1012.10 g. cm.	2704.55 g. cm.	2011.70 g. cm.

TABLE 13

DIRECT WORK—STATION 3

Depth. m.	June 17	July 9	August 2	August 29
0-5	47.25	232.50	154.50	177.75
5-10	50.00	200.00	396.00	428.00
10-15	58.50	65.00	571.00	500.50
15-20	40.50	36.00	594.00	252.00
20-25	17.25	25.30	483.00	80.20
25-30	11.20	9.80	294.00	60.20
30-35	9.95	3.30	161.70	49.50
35-40	7.60	1.90	89.30	43.70
40-45	4.30	0	43.00	38.70
45-50	0	0	19.20	38.40
50-55			10.60	34.45
55-60			8.70	31.90
60-65			9.45	28.35
65-70			6.80	27.20
70-75			7.30	25.55
75-80			3.90	19.50
80-85			4.15	16.60
85-90			4.40	13.20
90-95			4.65	13.95
95-100			0	9.80
100-105				5.15
105-110				5.40
110-115				0
115-120				0
120-123.4				0
	246.55 g. cm.	573.80 g. cm.	2865.65 g. cm.	1900.00 g. cm.

(3) that during the storm of July 30, the expenditure took place chiefly in the 10-20 metre area of the open portion of the lake, but in the 10-15 metre area of the more or less sheltered bay. In both cases considerable work was involved in distributing heat in the hypolimnion. It would appear that during the storm probably about 10,000 calories per sq. cm. of surface were distributed in the open waters of the lake requiring about 1500 g. cm. of work.

(4) that a considerable amount of work was expended in the deeper waters of the hypolimnion during August, since these waters continued to gain heat for some time following the storm.

In approximate terms then it may be said that in 1921, 2500 gram-centimetres of work per square centimetre of area were needed to distribute 30,000 gram-calories of heat per square centimetre of area in the waters of Lake Nipigon. This means, then, that our northern waters are essentially similar to those of more southerly distribution in the matter of summer heat income and its distribution. Where they differ, is in the length of the period from the time when the temperature begins to rise above 4°C. until a uniform temperature of 4°C. is again reached in the autumn. This summer period is of short duration. For example, ice may appear in Lake Nipigon in November and the lake be entirely frozen over by the end of December. The lake may not be free of ice again until the middle of May and occasionally not until early in June. In contrast to this, Cayuga Lake rarely freezes over and when it does so, the period lasts but little over a month (Birge and Juday, 1914). Strong summer winds would therefore appear to be of special importance in the northern regions. It is probable that in a season of little wind the summer heat income for Lake Nipigon would be very small. It is evident that the summer or growing period for the organisms in Lake Nipigon is comparatively short and it is hoped that data in regard to the effect of this condition in causing a slow rate of growth for fish may be presented later. However, it does not appear that the productiveness of such a lake in respect of those fish which can tolerate a short summer period, such as the common whitefish, will be any less than that of a lake with a longer summer period, if other factors such as those of food, oxygen supply, spawning conditions, etc., are equal. That the short summer period is one of the factors contributing to the absence of certain species of fish from our northern waters is probable, in that doubtless some species are unable, in the short time available, to accumulate sufficient reserve material to carry

them through the long winter period and allow them to spawn successfully in the spring.

Colour and Transparency

A white wooden disk 20 cm. in diameter was used in the determination of the transparency and a U.S. Geological Survey standard colorimeter for the colour. The following records were obtained by Mr. George Geiger:

No.	Date	Time	Location	Transparency feet	Colour
1	Sept. 11	10 a.m.	off Cedar Island		7
2	" 11	10 a.m.	east of Shakespeare Island	11.7	10
3	" 13	3.30 p.m.	2 mi. south of Echo Rock		7
4	" 16	2 p.m.	Sturgeon river	12.6	37
5	" 17	11 a.m.	Gull river		61
6	" 17	12 noon	Gull Bay		31
7	" 17	12.30 p.m.	Gull Bay		31
8	" 23	11.45 a.m.	Open waters south of Cedar Is.	17.0	7

In No. 2, the water seemed to be slightly turbid with clay. In determining the colours the standard tube was used empty since no distilled water was available. Many other tests in the open parts of the lake gave colour values of about 7.

The transparency of the open waters is thus high, comparing closely with those of Cayuga Lake (Birge and Juday, loc. cit.). The colour is slight in the open waters but is very dark brown in all of the streams tested and observed and persists to some extent in the shore waters of the lake, particularly around the mouths of the streams. This dark brown colour, no doubt, has some relation to the dark colouration of many shore-water fish such as the pike perch, lake trout and some of the whitefish.

Dissolved Gases

The results of the oxygen determinations (Tables 1, 2 and 3, and Figs. 4 and 5), for this season show:

(1) that from the middle of June to the middle of August

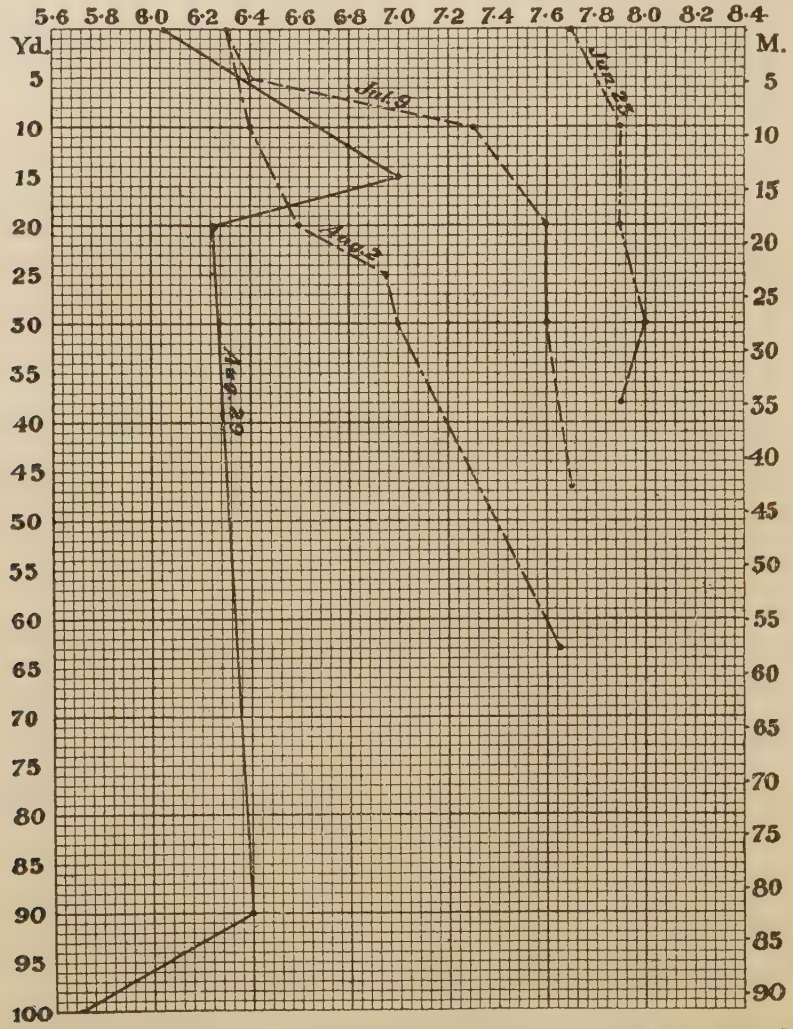


FIG. 4. Curves illustrating amounts of dissolved oxygen in cc. per litre, Station 3, Lake Nipigon.

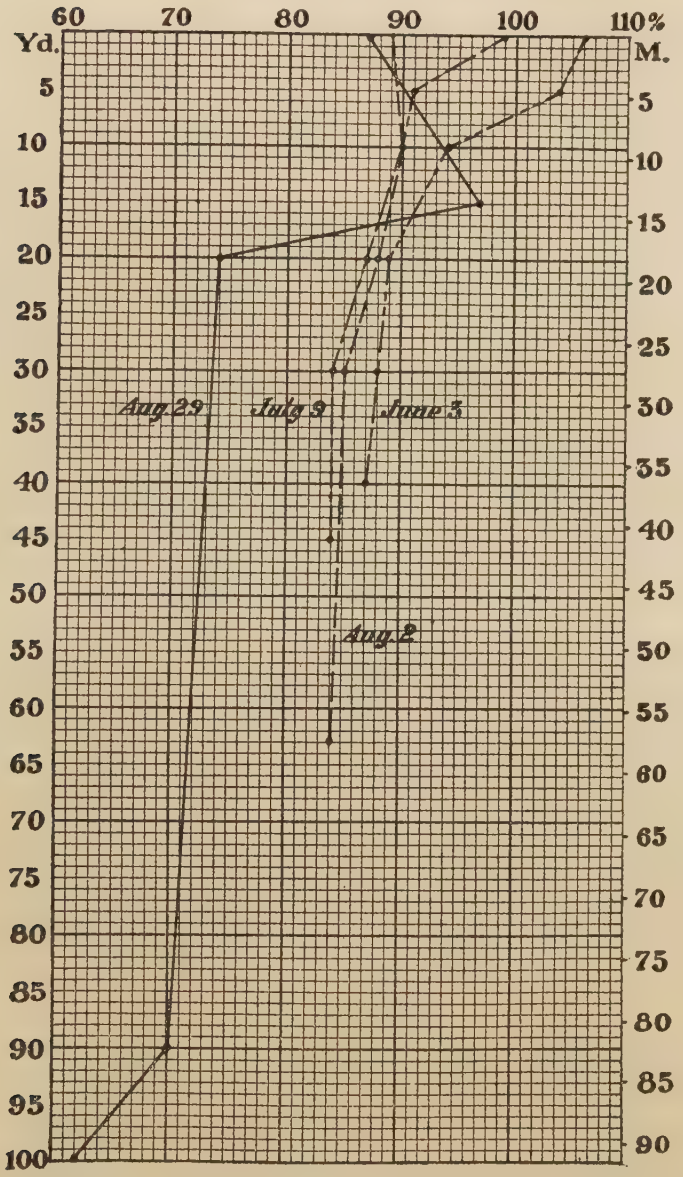


FIG. 5. Curves illustrating percentages of saturation of dissolved oxygen, Station 3, Lake Nipigon.

there was a plentiful supply of dissolved oxygen, the content seldom going below about 85% of saturation.

(2) that toward the end of August, the waters of the hypolimnion showed a marked reduction in oxygen content, the bottom waters at a depth of 100 yards having but 62% of saturation.

(3) that it is unlikely that the oxygen supply in the deep waters ever nears depletion and that in respect of dissolved oxygen, the lake is well suited to a deep-water fish fauna.

The results of the free carbon dioxide determinations (Tables 1, 2 and 3) show:—

(1) that at no time during the summer months was the amount of carbon dioxide large at any depth.

(2) that in the early part of the summer the upper waters contained the larger amounts but as the season advanced this condition was reversed, doubtless correlated with the growth of phytoplankton in the upper waters and the increase in decomposition processes in the bottom waters.

Conclusion

In conclusion it may be said (1) that Lake Nipigon possesses those features characteristic of large open bodies of water and does not appear to present any striking peculiarities in respect of physico-chemical conditions thus far investigated, except in regard to the short summer period; (2) that the peculiarities of its fauna and flora are the result of, at least the following three outstanding factors, (a) the short summer period, (b) the limited amount of shallow, protected water areas, (c) the isolation from the Great Lakes because of the falls and rapids in the single outlet.

Literature Cited

Bell, Robert, 1869. Report on the Geology of the Northeast Side of Lake Superior and of the Nipigon District. Report for 1866-1869, Geological Survey Canada, pp. 313-364.

Birge, E. A., and Juday, C., 1914. A Limnological Study of the Finger Lakes of New York. Bull. U.S. Bureau Fish., Vol. XXXII; document No. 791.

Birge, E. A., 1916. The Heat Budgets of American and European Lakes. Trans. Wisc. Acad. Sc., Arts and Letters, Vol. XVIII, p. 166.

Birge, E. A., 1916. The Work of the Wind in Warming a Lake. Trans. Wisc. Acad. Sc., Arts and Letters, Vol. XVIII, p. 341.

Birge, E. A., and Juday, C., 1921. Further Limnological Observations on the Finger Lakes of New York. Bull. U.S. Bureau Fish., Vol. XXXVII; document No. 905.

Birge, E. A., 1922. A Second Report on Limnological Apparatus. Trans. Wisc. Acad. Sc., Arts and Letters, Vol. XX, p. 533.

Coleman, A. P., 1922. Glacial and Pre-Glacial Lakes in Ontario. University of Toronto Studies: Publications of the Ontario Fisheries Research Laboratory, X.

Department of Game and Fisheries of Ontario, 1916-1920. Annual Reports, Toronto.

Hydro-Electric Power Commission of the Province of Ontario, 1907. Fifth Report, p. 14. Toronto.

McInnes, William, 1894. Summary Report on the Survey of Lake Nipigon. Geological Survey, Canada, New Series, Vol. VII, Part A, pp. 48-51.

Provincial Board of Health of Ontario, 1920. Sewage and Water. Bull. No. 7, Div. Sanitary Engineering.

White, James, 1915. Altitudes in the Dominion of Canada. Commission of Conservation, Canada, Ottawa.

Wilson, Alfred W. G., 1910. Geology of the Nipigon Basin, Ontario. Memoir No. 1, Dept. Mines, Geol. Survey Br., Canada, pp. 1-152.

UNIVERSITY OF TORONTO STUDIES

PUBLICATIONS OF THE
ONTARIO FISHERIES RESEARCH LABORATORY
No. 12

A PROVISIONAL LIST OF THE FISHES OF LAKE NIPIGON

BY

JOHN R. DYMOND
OF THE DEPARTMENT OF BIOLOGY
UNIVERSITY OF TORONTO

TORONTO
THE UNIVERSITY LIBRARY
1923

A PROVISIONAL LIST OF THE FISHES OF LAKE NIPIGON

The following brief account of the fishes of Lake Nipigon is based upon material obtained by the first field party of 1921. It contains a list of the species so far identified, with some reference to undetermined varieties, and is preliminary to a more comprehensive study and report, the material for which will, it is expected, be obtained during the summer of 1922.

The most striking feature of the fish fauna of Lake Nipigon, in view of its size, is the small number of species which inhabit it. As a result of the first season's work there fewer than thirty species were found in the waters of the lake itself. This is in striking contrast to what is found in other large lakes. Dymond (1922) gives ninety-one species of fish and two species of lamprey as occurring in Lake Erie, while Bensley (1915) records forty-eight species from Georgian Bay.

The small number of species occurring in Lake Nipigon is no doubt due in part to the physical conditions in the lake and in part to its geological history. Its waters have been isolated for long ages from the waters of the lower lakes, by means of falls sufficiently high to offer an insurmountable obstacle to the ascent of species from the south. Some species found in neighbouring lakes are absent from Lake Nipigon, which probably means that conditions in the lake are unsuitable for these forms.

The Sturgeon, *Acipenser rubicundus* Le Sueur, is fairly abundant. During 1919, 17,595 pounds were taken from the lake. The largest specimen recorded weighed 99 pounds.

The Long-nosed or Northern Sucker, *Catostomus catostomus* (Forster), and the Common Sucker, *Catostomus com-*

mersonii (Lacépède), are very abundant. The former, especially, is taken in considerable numbers in deep waters in gill nets set for whitefish and lake trout. The Common Sucker is found in shallower water. On account of the distance from market it is not profitable to ship these species, and those taken in the nets are consequently destroyed.

Only four species of *Cyprinidae* were found in the lake. In the order of their relative abundance they are, the Spottailed Minnow, *Notropis hudsonius* (De Witt Clinton), Lake Chub, *Couesius plumbeus* (Agassiz), Long-nosed Dace, *Rhinichthys cataractæ* (Cuvier and Valenciennes), and the Shiner, *Notropis atherinoides* Rafinesque. None of them appears to be at all common, and no specimens of any of them were identified in the stomachs of fishes. *Leuciscus neogæus* (Cope) is found in a number of small lakes in the neighbourhood, but has not been taken from Lake Nipigon itself. This species has not been previously recorded from Ontario.

Speckled Trout, *Salvelinus fontinalis* (Mitchill), of unusual size are taken on the line in the Nipigon river. The largest one taken in recent years weighed $14\frac{1}{2}$ pounds, but specimens of five pounds in weight are quite commonly secured. They are also found in the fishermen's pound nets, but fish so taken are returned to the water.

The Lake Trout, *Cristivomer namaycush* (Walbaum), is, next to the whitefish, the most important commercial species of Lake Nipigon. It is usually taken in gill-nets in deep water, but a very dark, slim form is commonly taken in pound nets in shallow water. The significance of the latter variety is to be further investigated.

The Round Whitefish, *Coregonus quadrilateralis* Richardson, is not uncommon. It appears to remain in comparatively shallow water. On account of its slimness, it is not taken in the fishermen's nets.

The Common Whitefish, *Coregonus clupeaformis* (Mitchill), is the most important commercial species in the lake. The fishermen recognize two types, *viz.*, the deep-water and the shallow-water forms. In general, the latter is a darker, slimmer fish than the former, although both types are taken

in deep water. The two extremes are connected by intergradations. The variation in colour, form, and other characters dependent on depth and other factors has not yet been fully investigated.

The Ciscoes or Lake Herrings, *Leucichthys* spp., have not yet been definitely worked out, but there appear to be at least three varieties. The commonest form is a dark fish with black fins. It averages about $1\frac{1}{2}$ pounds in weight. A larger, lighter-coloured form, locally known as "Tullibee", is occasionally taken in the gill-nets in deep water. A much smaller variety with longer head and very pale fins appears to be confined to comparatively shallow water.

The Pike, *Lucius lucius* (Linn.), is common in small bays along shore, and is occasionally taken in the fishermen's nets.

The Brook Stickleback, *Eucalia inconstans* (Kirtland), is much less common than the nine-spined Stickleback, *Pygosteus pungitius* (Linn.). The latter is perhaps the most abundant of the smaller species inhabiting the lake, some specimens being taken in nearly all seine catches. It was also commonly found in the stomachs of Pike Perch, and less commonly in Lake Trout, Ling, Pike, and Whitefish.

The Trout Perch, *Percopsis omisco maycus* (Walbaum), appears to be common. A few specimens were taken from the stomachs of predaceous species, and thousands were taken in July in a specially constructed bag net set in a stream a few hundred yards above where it enters the lake.

The Small-mouthed Black Bass, *Micropterus dolomieu* Lacépède, is believed not to occur naturally in Lake Nipigon. Small specimens of the year were taken in the seine near the foot of Orient Bay in July. They were probably the progeny of some parent fish planted the previous season.

The Yellow Pickerel or Pike Perch, *Stizostedion vitreum* (Mitchill), is an important commercial species in Lake Nipigon. It is taken in pound nets in shallow water. The maximum size attained is about nine pounds.

The Yellow Perch, *Perca flavescens* (Mitchill), was taken in considerable numbers in small bays by means of the seine.

For some reason the species does not reach a very large size, the largest specimen secured being six inches in length.

The only species of darter taken was the Tessellated Darter, *Boleosoma nigrum* (Rafinesque.) It was commonly taken in the seine in shallow water.

A number of specimens of the Miller's Thumb, *Cottus ictalops* (Rafinesque), and of *Uranidea gracilis* (Heckel), were taken about the middle of June in a specially constructed bag net set in a stream a short distance from where it enters the lake. Partly digested specimens, too fragmentary for definite determination, taken from the stomachs of ling may represent a third species of the family *Cottidae.*

The Ling, *Lota maculosa* (Le Sueur), is very common in deep water, and large numbers are taken in gill nets set for Whitefish.

Although this list is not extensive, it includes the principal commercial species characteristic of the Great Lakes. Its deficiency is mainly in *Cyprinidae* and other small forms. To what extent this deficiency limits the productivity of the lake by curtailing the food of the larger predaceous species cannot be estimated until other bodies of water, rich in the smaller species, have been investigated.

Literature Cited

Bensley, B. A., 1915. The Fishes of Georgian Bay. Contrib. Canad. Biol. 1911-14, Fasc. II, Fresh Water Fish and Lake Biology. Biological Board of Canada, Suppl. 47th Ann. Rep. Dept. Marine and Fisheries, Fisheries Branch, Ottawa.

Dymond, J. R., 1922. A Provisional List of the Fishes of Lake Erie. University of Toronto Studies. Biological Series. Pub. Ontario Fisheries Research Laboratory, No. 4.

UNIVERSITY OF TORONTO STUDIES

PUBLICATIONS OF THE
ONTARIO FISHERIES RESEARCH LABORATORY
No. 13

THE PLANKTON OF LAKE NIPIGON AND ENVIRONS

BY

N. K. BIGELOW

OF THE DEPARTMENT OF BIOLOGY
UNIVERSITY OF TORONTO

TORONTO
THE UNIVERSITY LIBRARY
1923

THE PLANKTON OF LAKE NIPIGON AND ENVIRONS

The following preliminary record of the more minute fauna and flora of Lake Nipigon and vicinity is the result of extensive collections made during the summer of 1921. The material studied was obtained from four sources:—

(1) By means of a vertical closing net, plankton samples were taken from the open waters at all depths. Three stations were established, and visited regularly. Station I was located off the mouth of the Nipigon River; Station II, in the deep water of Pijitawabik Bay (Orient Bay), directly opposite the village of Macdiarmid; Station III, in the open waters opposite the mouth of Sandy River. The usual type of closing net was used, made of bolting silk, size No. 20, and vertical tows were made through five and ten yard intervals. The quantitative results will be presented in a later paper.

(2) Surface tows were made in many places in the lake and in the lower portions of some of the larger streams.

(3) Many interesting forms were secured by sweeping with a small, conical net among aquatic vegetation in streams, bayous, ponds, pools, cold springs, etc.

(4) The stomach contents of many species of fish yielded much valuable data. Young fish, particularly the young of the common sucker (*Catostomus commersonii*) were found to be excellent collectors of small organisms. Several hundred small suckers were examined, and their digestive tracts were found each to contain from 30 to 50 or more different species of microscopic animals and plants. When from two to four centimetres in length, they were found to have subsisted almost entirely upon plankton. Slightly larger specimens taken a little later in the season were found to have fed upon the surface of the bottom ooze, where myriads of *Rotatoria*, *Cladocera*, *Diatoms*, etc., occurred.

In the lists of organisms mentioned in this paper the following designations are used: A. = abundant; V.C. = very common; C. = common; F. = fairly common; I. = infrequent; R. = rare.

An asterisk after the name of an organism denotes that the species had been taken as food by the young suckers previously mentioned.

ALGAE

CLASS MYXOPHYCEAE

The abundance of blue green *Algae* in Lake Nipigon and its vicinity was found to be insignificant in comparison with that of the diatoms; nevertheless, a considerable number of species were found to occur. The only genera found in the open-water plankton were *Microcystis*, *Anabaena*, and *Aphanizomenon*. The other genera occurred in creeks, bayous, ponds, and pools.

ORDER COCCOGONEALES

FAMILY CHROOCOCCACEAE

Chroococcus limneticus Lemmermann I.

Chroococcus turgidus Nägeli * F.

Coelosphaerium sp. I.

Merismopedia elegans Braun * F.

Microcystis aeruginosa Kützing * A. Although this species was not present in sufficient numbers to be the direct cause of lake bloom, it contributed to this formation by mingling with the more abundant *Anabaena*.

Microcystis flos-aquae Kirchner * V.C.

Aphanocapsa sp. * I.

Aphanothece sp. I.

Gloeothece sp. I.

Dactylococcopsis sp. * I.

ORDER HORMOGONEALES

FAMILY OSCILLATORIACEAE

Lyngbya birgei Smith * I.

Oscillatoria sp. F. Myxophytes of this genus were found only in small pools.

FAMILY NOSTOCACEAE

Nostoc sp. Pale green colonies of a species of this alga were found attached to weeds in a sluggish creek near Orient Bay. The colonies were spherical, but only about 8 mm. in diameter.

Anabaena circinalis Rabenhorst A.

Anabaena lemmermanni Richter * A. Long strips of lake bloom in the latter part of July and in August were found, on microscopic examination, to be masses of spores of this species, from which the surrounding filaments had disintegrated. Masses of the same kind of spores were found occasionally in the digestive tracts of young suckers.

Aphanizomenon flos-aquae Ralfs. R.

FAMILY RIVULARIACEAE

Rivularia sp. F.

CLASS BACILLARIACEAE

Of all the minute organisms found in Lake Nipigon diatoms were by far the most numerous. They occurred in prodigious numbers in the plankton, being often so very numerous that other organisms had to be specially searched for. They were also very abundant in the ooze and among aquatic vegetation. A large percentage of the food of bottom-feeding fish was found to be diatomaceous. The genera of diatoms found in open-water plankton in order of greatest abundance were *Melosira*, *Asterionella*, *Tabellaria*, *Synedra*, *Stephanodiscus*, and *Fragillaria*.

FAMILY MELOSIRACEAE

Melosira granulata Ehr. * A. During the month of June this diatom was so abundant that, if the net were towed behind a motor-boat at Station I or Station II for five minutes, it would contain at least half-a-pint of greenish-coloured plankton, which was found to be composed of about 95% of this particular organism. Quantitative methods of counting sometimes showed as many as 145,000 filaments

per cubic centimetre. By the middle of July, *Asterionella* was much commoner on the surface, but *Melosira* was still quite common in the deeper water. In the latter part of August, *Melosira* had become a rather uncommon species.

FAMILY COSCINODISCACEAE

Stephanodiscus sp. * C.

FAMILY RHIZOSOLENIDACEAE

Rhizosolenia sp. F. A diatom of this genus was fairly common in the plankton of Station II during the month of June. The species was very slender, and possessed very long indistinct terminal spines. In all probability it was a much commoner organism than appearances would indicate as its extreme transparency rendered it difficult to see.

FAMILY NAVICULACEAE

Pleurosigma sp. * I.
Pinnularia sp. * V.C.
Navicula sp. * V.C.
Stauroneis sp. * F.

FAMILY CYMBELLACEAE

Amphora sp. * I.
Cymbella sp. * C.
Cocconema sp. * V.C.
Encyonema sp. * R.

FAMILY GOMPHONEMIACEAE

Gomphonema sp. * C

FAMILY ACHNANTHACEAE

Achnanthes sp. * C.

FAMILY NITZSCHIACEAE

Nitzschia sp. F.

FAMILY AMPHIPRORACEAE

Amphiprora sp. * I.

FAMILY SURIRELLACEAE

Campylodiscus sp. * I.
Cymatopleura sp. * C.
Surirella sp. * V.C.

FAMILY DIATOMACEAE

Denticula sp. R.

FAMILY MERIDIONACEAE

Meridion circulare (Gren) C. Large brown masses of this species were found in a cold spring near Fairlock.

FAMILY FRAGILLARIACEAE

Synedra sp. * V.C.
Fragillaria sp. * C.
Asterionella formosa Hass. A. Next to *Melosira* this was the most abundant organism of the open-water plankton. It appeared to be commonest after *Melosira* had declined in numbers, but this may have been due, somewhat, to the fact that the thinning out of the latter rendered it more conspicuous. Plankton composed of *Asterionella* is very white in contrast to the green *Melosira*.

FAMILY TABELLARIACEAE

Tabellaria fenestrata Kützing * A. This was the third commonest diatom. It reached its culminating numbers in late summer, when *Asterionella* had greatly decreased and *Melosira* was scarce. Plankton composed of this species was white, but not so purely white as that composed of *Asterionella*. At the end of August the base of the stems of rushes standing in shallow water near the head of Orient Bay were found to be encased in a coating of whitish, slimy material which was found to be entirely composed of this *Tabellaria*. Apparently the long zigzag filaments had become tangled together and, being washed by the waves, had collected around the stems of the rushes. Several young suckers taken near this locality at this time had been feeding almost entirely upon this material as the contents of their

alimentary tracts averaged from 95% to 98% *T. fenestrata*.

Tabellaria flocculosa Kützing * V.C.

FAMILY EPITHEMIACEAE

Epithemia sp. * V.C.

Ceratoneis arcus Kützing F. One plankton tow from Sandy Bay early in June contained fair numbers of this species; otherwise it was scarce.

CLASS HETEROKONTEAE

ORDER HETEROCOCCALES

FAMILY OPHIOCYTIACEAE

Ophiocytium capitatum Wolle C. Masses of filamentous algae in a sluggish creek near the head of Orient Bay were found to contain numbers of this species.

Ophiocytium arbuscula (Braun) C. This species was found at the same time and place as the preceding.

FAMILY BOTRYOCOCCACEAE

Botryococcus braunii Kützing * A. The only other organism responsible for lake bloom besides *Anabaena lemmermanni* was this *Botryococcus*. It produced long strips of reddish colour in the latter part of July on the surface of the lake.

ORDER HETEROTRICHALES

FAMILY TRIBONEMACEAE

Tribonema minor (Wille) V.C. This alga was found only in tiny pools along the railway in June.

CLASS CHLOROPHYCEAE

ORDER VOLVOCALES

FAMILY VOLVOCACEAE

Pandorina morum Bory F.

Eudorina elegans Ehr. C.

Volvox aureus Ehr. C.

ORDER PROTOCOCCALES

FAMILY PALMELLACEAE

Sphaerocystis sp. F.

Tetraspora lacustris Lemmermann I.

Tetraspora sp. F. Long cylindrical masses of an alga of this genus occurred in pools along the railway near Macdiarmid in the month of June. These colonies were about 2 centimetres in length by 1/5 as wide.

FAMILY DICTYOSPHAERIACEAE

Dictyosphaerium sp.

FAMILY AUTOSPORACEAE

Oocystis sp. * V.C.

Tetraedron limneticum Birge R.

Ankistrodesmus falcatus Ralfs. R.

Quadrigula sp. R.

Kirchneriella lunaris Mobius * I.

Scenedesmus bijuga Lagerheim * I.

Coelastrum cambricum Archer * I.

Coelastrum proboscidium Bohlin R.

Sorastrum americanum Bohlin I.

Sorastrum spinulosum Nägeli I.

Actinastrum hantzschi Lagerheim F.

FAMILY HYDRODICTYACEAE

Pediastrum duplex Meyen * V.C.

Pediastrum boryanum Turpin * V.C.

Pediastrum tetras Ehr. I.

Pediastrum biradiatum Meyen R.

None of the *Algae* belonging to the orders *Volvoccales* or *Protococcales* were very abundant members of the flora of the Nipigon region. The only plankton in which they were found was that of bays and creeks.

ORDER ULOTRICHALES

FAMILY ULOTRICHACEAE

Ulothrix zonata Kützing C. Stones in shallow water near the margin of the lake were covered with a brown matting composed of this alga.

FAMILY CHAETOPHORACEAE

Chaetophora pisiformis Ag. C. Beautiful green masses of this species were attached to sticks and stones in a sluggish creek.

Coleochaete sp. F. The flattened colonies of this alga were found on the under surface of water-lily leaves.

ORDER SIPHONOCLADIALES

FAMILY CLADOPHORACEAE

Cladophora sp. A. The bottom of the lake for some distance from the margin was found often carpeted with a species of this plant. It is rather important as food for sturgeon, whitefish, and other bottom-feeding fish.

ORDER CONJUGALES

FAMILY ZYGNEMACEAE

Spirogyra sp. V.C. Several species of this alga occurred in ponds, creeks, and along the margin of the lake.

Zygnaema stellinum Ag. C. This species was common in sluggish creeks near Orient Bay.

Mougeotia viridis (Kützing) * A. This was the commonest species of the *Conjugales*, and was found in ponds, streams, and creeks, as well as at the margin of the lake.

FAMILY DESMIDIACEAE

Desmids occurred in considerable numbers in plankton swept from among weeds in sluggish creeks and bayous of the lake. They were especially numerous near the head of Orient Bay where the water is rather shallow. Weedy bayous occur along the bank and several sluggish creeks flow into the lake at this point, forming ideal conditions for their growth. Although many species of desmids were found they were never abundant enough to be an important constituent of the plankton. The following list contains only the recognized forms, besides which a great number of others occurred:

Penium sp. * I.

Closterium lunula Ehr. * I.

Closterium lineatum Ehr. C.
Closterium rostratum Ehr. V.C.
Docidium baculum (Breb.) * C.
Staurastrum coronulatum Wolle * I.
Staurastrum orbiculare Ralfs I.
Micrasterias rotata Ralfs * V.C.
Micrasterias furcata Ralfs F.
Micrasterias truncata Ralfs F.
Micrasterias americana Kutz F.
Cosmarium octhodes Nord. * V.C.
Sphaerozosma pulcrum Bailey I.
Hyalotheca sp. * F.
Desmidium swartzii Ag. * V.C.
Aptogonum baileyi Ralfs * R.
Gymnozyga sp. R.

PROTOZOA

CLASS RHIZOPODA

As might be expected these organisms were found mainly in the ooze and in the digestive tracts of bottom-haunting fish which had fed upon this material. With one or two exceptions none were found in open-water plankton except an occasional adventitive individual

ORDER GYMNAMOEBIDA

FAMILY AMOEBIDAE

Amoeba proteus Leidy F.

ORDER TESTACEA

FAMILY ARCELLIDAE

Arcella vulgaris Ehr. * F.
Arcella dentata Ehr. * R.
Centropyxis aculeata Stein * V.C.
Lecquereusia modesta Rhumbler * C.
Difflugia corona Wallich * V.C.
Difflugia lobostoma Leidy * V.C. Although *Difflugia* is usually considered to be a bottom-haunting organism, one small round form, answering in every way the description of

D. lobostoma, appeared in such numbers in the open-water plankton as to preclude the possibility of its being adventitious there. It was found most commonly on the surface, but occurred at all depths.

Difflugia pyriformis Perty * V.C.
Difflugia acuminata Ehr. * V.C.
Nebela sp. * R.

Order Testacea

Family Euglyphidae

Campascus ? * F. The test of an undetermined Sarcodinid protozoan was occasionally taken as food by small suckers. This rhizopod resembles *Campascus*, but the processes of the shell are closer together and more terminal than in *Campascus cornutus*.

Cyphoderia ampulla Ehr. * V.C.
Cyphoderia ampulla var. *papillata* Wailes * I.
Assulina seminulum Ehr. * F.
Euglypha alveolata Dujardin * C.

In all probability several species of *Euglypha* occurred.

The list of rhizopods would probably be greatly extended if sphagnum bogs and other likely spots had been specially searched for them.

Class Actinopoda

Order Aphrothroracida

Actinophrys sol Ehr. F.

Order Chalathoraca

Pompholyxophrys punicea Archer I.

Class Zoomastigophora

Order Euglenida

Family Euglenidae

Trachelomonas hispida Stein I.
Phacus longicaudus Ehr. I.

CLASS PHYTOMASTIGOPHORA

ORDER CHRYSOFLAGELLIDA

Mallomonas sp. F. These organisms were commonest in a plankton tow, not on the surface, but at a depth of about 8 metres, near North Bay on July 19.

Spongomonas sp. F. Long, slender, yellowish-brown colonies, often twisted and irregular, were found among weeds in a sluggish creek near Orient Bay during the latter part of August.

Rhipidodendron splendidum Stein F. Small masses of the tubules of this flagellate were found at the same time and place as the colonies of the preceding species.

Synura uvella Ehr. F. Colonies of these protozoa were fairly common in ponds and pools.

Dinobryon sertularia Ehr. A. This species was sometimes abundant during the month of June in plankton from bays and creeks.

Dinobryon bavaricum Imhof. F. Very typical example of this species occurred during the latter part of June in plankton from Station II. It was always found with the preceding species, but never was so abundant.

Peridinium sp. F.

Ceratium hirundinella Müller A. This species was occasionally abundant during the month of July in plankton from bays and creeks.

CLASS CILIATA

The ciliates included in the following list were mostly found in ponds and pools. *Codonella* is a typical open-water planktont and was found at all depths. *Vorticellae* were attached to colonies of *Anabaena* in the lake.

ORDER HOLOTRICHA

Coleps hirtus Ehr. C.
Didinium nasutum Müller F.
Nassula ornata Ehr. R.
Trachelius ovum Ehr. F.

Urocentrum turbo Müller C.
Ophryoglena atra Ehr. I.
Colpidium sp. F.
Cyclidium sp. F.
Paramoecium caudatum Ehr. C.

ORDER HETEROTRICHA

Stentor coeruleus Ehr. C.
Halteria grandinella Müller C.
Codonella sp. V.C.

ORDER HYPOTRICHA

Oxytricha sp. C.

ORDER PEROTRICHA

Vorticella sp. V.C. A number of species occurred.

Ophrydium eichhornii Ehr. I. Two beautiful green colonies of this ciliate were found attached to vegetation in a creek.

Pyxicola sp. I.

CLASS SUCTORIA

Podophrya sp. F. A pear-shaped species of this genus, with a long stalk, was often found attached to the legs and antennae of *Limnocalanus macrurus* and *Mysis relicta*. The crustaceans were often taken from a depth of 60 metres or more.

ROTATORIA

Although a great many species of the wheel animalcules were found, no one species was conspicuously abundant. Forming, as they do, a large percentage of the first food of young fishes, their economic importance is considerable.

ORDER PLOIMA

FAMILY NOTOMATIDAE

Eosphora sp. F. In pools along the railroad track.
Notomata aurita Müller I. In weedy creeks.
Diaschiza I. Several sp. In weedy creeks.
Cephalodella forficula Ehr. I. In weedy creeks.
Monommata orbis Ehr. I. In weedy creeks.

FAMILY BRACHIONIDAE

Brachionus capsiflorus Pallas R. Only one specimen of this species and genus was found during the season. It was a typical example of the form previously known as *Brachionus bakeri* with long, gracefully curved cephalic and posterior spines. It was found in a small pond close to Macdiarmid village.

FAMILY BRACHIONIDAE

Platyias quadricornis Ehr. C. This rotifer was found throughout the summer among weeds and algae in small pools and sluggish creeks, but never in the lake. *Keratella cochlearis* Gosse * V.C. This proved to be the most widely distributed species in the region under discussion, and was found in all bodies of water examined except in temporary pools. In the lake it occurred at all depths from the surface down to a hundred metres throughout the season.

Keratella quadrata Müller F. This was an open-water form and was found from the surface down to a depth of 100 metres. It was by no means as common as the preceding species, three individuals being the greatest number noted in any one plankton haul. The rotifer was taken from the latter part of July until the end of August. The individuals had very large posterior spines, broad at their bases, and widely divergent.

Keratella serrulata Ehr. * I. This species was found only in creeks and bays. The specimens showed the typical, prominent hexagons on the lorica and roughened projections on the egg carried, as well as on the lorica.

Anuraeopsis fissa Gosse F. During the month of June this species occurred in a small pond close to Macdiarmid village.

Notholca longispina Kellicott * V.C. Next to *Keratella cochlearis*, this was the commonest rotifer. It occurred throughout the summer at all depths from the surface down to 100 metres. It was also found in creeks and some of the larger ponds.

Notholca striata Müller * C. Although found occasionally in open-water plankton this species was commonest in bays and creeks. Nearly all small suckers taken during July and August near Orient Bay had eaten it. Besides typical *Notholca striata*, the forms of this species which were previously designated as *Notholca thalassia* and *Notholca acuminata* were frequently found.

Notholca foliacea Ehr. * I. This species was taken a few times in plankton from Station II. A few were eaten by suckers in July and August.

FAMILY MYTILINIDAE

Mytilina mucronata Müller * C. This species was found in weedy creeks throughout the season.

FAMILY EUCHLANIDAE

Euchlanis deflexa Gosse * F.
Euchlanis dilatata Ehr. I.
Diplois propatula Gosse F.
Lecane ohioensis (Herrick) * C.
Lecane sulcata Gosse * C.
Lecane luna (Müller) * V.C.
Lecane leontina (Turner) I.
Monostyla bulla Gosse * C.
Monostyla lunaris Ehr. * F.
Monostyla quadridentata Ehr. R.

Members of this family and the next are found in bays and creeks among weeds and are frequently fed upon by young fish.

FAMILY LEPADELLIDAE

Lepadella ovalis Müller * F.
Lepadella acuminata Ehr. * F.
Lepadella ehrenbergii (Perte) R. A single individual was taken from the digestive tract of a young sucker.
Colurella adriatica Ehr. * F.
Colurella uncinatus (Müller) * I.
Squatinella longispinatum Tatem I. This species was found in plankton swept from among weeds in the Pustagone

River on August 23. A peculiar *Squatinella* was also found in this material which resembled a typical *S. longispinatum* except that it had a second long dorsal spine on the lorica some distance back of the first. This may be only a variation, as several quite normal individuals of this species occurred in the same material.

FAMILY TRICHOTRIIDAE

Trichotria pocillum Müller * F.

Macrochaetus collinsii (Gosse) I. Eight or nine individuals of this strange rotifer were taken from creeks and one from some plankton in the bay near Orient Bay village. The only other examples of this rotifer ever seen by the writer were from an entirely different environment, namely, in a small muddy pond in a cow-pasture near Cedar Rapids, Iowa.

Scaridium longicaudum (Müller) F. This rotifer was found among weeds in creeks.

Scaridium eudactylotum Gosse R. This rare rotifer was found but once in plankton from among weeds near the mouth of the Pustagone River.

Diurella tenuior (Gosse) * C.

Diurella stylata Eyferth * I.

Trichocerca cristata Harring F.

Trichocerca cylindrica (Imhof) I.

Trichocerca lata Jennings * C.

Trichocerca longiseta Schrank F.

Trichocerca multicrinis (Kellicott) I.

Several rotifers of this family not satisfactorily determined are not listed.

FAMILY CHROMOGASTRIDAE

Chromogaster ovalis (Bergendae) C. In middle and late summer this rotifer was rather common in open-water plankton, but was never found at any great depth.

FAMILY GASTROPODIDAE

Gastropus stylifer Imhof * V.C. This was a very common surface form in all parts of the lake throughout the season. It was also found in creeks and large ponds.

Ascomorpha eucadis Perty R. One rotifer of this species was taken from weeds growing on the bottom of a pond.

FAMILY SYNCHAETIDAE

Synchaeta stylata Wierzejski V.C. Throughout the season this species was very common in the lake. It was occasionally taken at considerable depths, but was much commoner near the surface. When this species was numerous its spiny resting eggs were sometimes common in the plankton.

FAMILY POLYARTHRIDAE

Polyarthra trigla Ehr. * V.C. In creeks, ponds, and bayous as well as in the open waters of the lake, this species was common throughout the season. It was commonest in the latter part of summer. It is mainly a surface form and was rarely taken in deep water.

FAMILY PLOESOMIDAE

Ploesoma lenticulare (Herrick) * V.C. This also was a surface form occurring throughout the summer in all parts of the lake.

Ploesoma hudsoni Imhof I. This species was found in similar conditions to the preceding, but was only seen about a dozen times.

FAMILY ASPLANCHNIDAE

Asplanchna sp. I. A large rotifer of this genus was occasionally found in open-water plankton. The specimens were in too poor a condition when examined to permit of specific determination.

FAMILY TESTUDINELLIDAE

Testudinella patina Hermann C. This beautiful discoid rotifer was common throughout the summer in weedy ponds and creeks. It was frequently attacked by some parasitic organism which filled its lorica with short cylindrical spores. Often the rotifer would be still alive when its shell had

become so filled with these spores as to hide its internal organs completely from view.

ORDER FLOSCULARIACEAE

FAMILY FLOSCULARIDAE

Floscularia ringens (Linn.) I. On August 3 this species was found attached to weeds in South Bay.

Limnias melicerta Weisse I. The beautiful annulated tubes of this rotifer were swept from among weeds in a small creek near Orient Bay the latter part of August.

FAMILY CONOCHILIDAE

Conochilus unicornis Rousselet I. Occasionally clusters of this rotifer were taken in open-water plankton.

Lacinularia sp. I. Masses of an undetermined species of this genus were attached to weeds in South and Orient Bays.

ORDER COLLOTHECACEA

FAMILY COLLOTHECIDAE

Collotheca algicola (Hudson) I. This rotifer was found in colonies of *Rivularia* attached to weeds in a creek near Orient Bay.

Collotheca ambigua (Hudson) F. This rotifer was found attached to weeds in sluggish streams.

Collotheca cornuta (Dobie) I. This species occurred under conditions similar to the above mentioned form.

Collotheca mutabilis (Hudson) F. This is a typical open-water planktont, free floating and never attached to weeds. It occurred in many parts of the lake, but always close to the surface.

ORDER BDELLOIDA

FAMILY ADINETIDAE

Adineta sp. F. A species of this genus occurred in creeks and ponds and a similar, if not identical, one was taken from water contained in the leaves of pitcher plants.

FAMILY PHILONINIDAE

Rotaria rotatoria (Pallas) C.
Rotaria citrina Ehr. F.
Rotaria neptunia Ehr. R.
Philodina roseola Ehr. I.
Dissotrocha aculeata Ehr. I.

ARTHROPODA

CLASS CRUSTACEA

ORDER COPEPODA

FAMILY CENTROPAGIDAE

Epischura lacustris Forbes C. This large copepod was found near the surface in the open water of the lake and in creeks and bays. Although not frequently found in the plankton, its abundance is attested by the numbers found to have been eaten by small fishes. The stomach of a young small-mouth black bass (*Micropterus dolomieu*) contained 82 of these copepods, while 67 were found in another individual. These two fishes were 2.6 centimetres in length and were taken on July 19 at Orient Bay.

Diaptomus sicilis Forbes V.C. This was probably the commonest species of *Diaptomus* in Lake Nipigon. It was found in all parts of the lake, often at considerable depths but not in the deepest water.

Diaptomus minutus Lilljeborg C. This *Diaptomus* was not quite so common as the preceding form. It was not found until the middle of July, whereas *D. sicilis* occurred from the first of June. *D. minutus* was first found in creeks and shallow water, but as the season advanced it was taken in the surface waters of the more open parts of the lake. Quite often while making a series of vertical plankton hauls through various intervals from the bottom to the surface, *D. minutus* was found to occur in the first few metres below the surface after which *D. sicilis* would extend for a few metres more to be succeeded by *Limnocalanus*. Rather infrequently, late in the summer, both species of *Diaptomus* occurred together.

Limnocalanus macrurus Sars V.C. This copepod was found in numbers in the deeper, cooler waters of the lake. It was common from 40 to 50 metres below the surface. Sometimes over 200 individuals would be taken in a 5-metre haul at these depths. Probably this gives a very erroneous idea of its actual numbers as it is a large active creature which would swim away from the net and not be caught in the same way as the smaller constituents of the plankton, such as diatoms and rotifers. Its numbers must be enormous indeed, judging from the stomach contents of whitefish and ciscoes. Four ciscoes were found to have their alimentary tracts packed with fragments of countless thousands of this crustacean.

FAMILY CYCLOPIDAE

Cyclops * V.C Specific identifications in this genus were not attempted, although several species doubtless occur. Although often eaten by many kinds of fishes, it never was found in great numbers in any of the stomachs examined. A peculiar dark-coloured, opaque cyclops was taken on August 30 from a small pond near Fairlock.

FAMILY HARPACTICIDAE

Canthocamptus stapylinus (Jurine) * C.
Canthocamptus hiemalis (Pearse) * I.
Canthocamptus minutus (Claus.) * F.

FAMILY ERGASILIDAE

Ergasilus sp. I. A species of this copepod was found in the stomach of a ling which had been feeding upon the nine-spined stickleback (*Pygosteus pungitius*). Doubtless the parasite came from the latter fish.

ORDER OSTRACODA

Ostracods were of very great importance indeed as food for bottom feeding fish, as nearly all examined had eaten at least some of these crustaceans. A very few of the numerous species were identified.

Cypria sp. C. A species of this genus was taken from the stomach of a trout perch (*Percopsis omisco maycus*) from the Pustagone River.

Candona sp. V.C. This genus is fed upon by whitefish whenever it can be found. One whitefish's stomach was packed with fragments of the shells and appendages of thousands of these ostracods.

Spirocypris tuberculata Sharpe F. This species was found in weedy ponds.

Limnocythere reticulata Sharpe F. Although this is supposed to be a pond form, an ostracod answering the description of this species was found in a young sucker taken the latter part of summer near Macdiarmid.

Illyodromus pectinatus Sharpe R. One individual was found in the stomach of a common sucker, 26 cm. in length, on July 12.

ORDER CLADOCERA

At least 42 species and several varieties of these crustaceans were found in Lake Nipigon and its vicinity. They were found to be of great economic importance, as the food of fishes was sometimes very largely composed of them. Some outstanding points of interest concerning this group in the area under consideration are the absence of *Holopedium* and the frequency of species such as *Rhynchotalona falcata*, *Alonella nana*, *Pleuroxus hastatus*, and other *Cladocera* not supposed to be particularly common.

FAMILY SIDIDAE

Sida crystallina (Müller) * V.C. This entomostracan was not found in the more open parts of the lake, but was common in bays and creeks. Its frequency is shown by the fact that 40 out of 57 small suckers had eaten it, and in many instances over half of their food consisted of this crustacean. It was also eaten by the young of the smallmouth black bass (*Micropterus dolomieu*) and other fishes.

Latona setifera (Müller) I. One specimen of this clado-

ceran was found in ooze near Orient Bay, and three or four others in the stomachs of suckers, larger, with one exception, than those previously mentioned.

Diaphanosoma brachyurum (Liéven) * C. The fact that this species was not often found in fish stomachs is probably due to the fact that it is very perishable and its post-abdomen small and easily overlooked.

Diaphanosoma leuchtenbergianum Fischer * C.

FAMILY DAPHNIDAE

Daphnia pulex (de Geer) * V.C. The contrast in numbers between *Daphnia pulex* in Lake Nipigon and in Lake Erie was very noticeable. In the latter lake the ciscoes taken during the summer were found to have fed throughout the season upon countless thousands of this species. In Lake Nipigon only 13 out of 57 small suckers had eaten it during the latter part of July at Orient Bay. In fact, this cladoceran occurred more commonly in ponds and pools than in the lake. It was found to be very common, for example, in barrels of water on the railway bridge near Macdiarmid.

Daphnia pulex var. *minnehaha* Herrick F. This variety was found only in one small pond near Macdiarmid.

Daphnia retrocurva Forbes * F.

Daphnia longispina var. *hyalina* Leydig form *galeata* * C.

Simocephalus vetulus (Müller) I.

Scapholeberis mucronata (Müller) * C.

Ceriodaphnia reticulata (Jurine) C.

Ceriodaphnia lacustris Birge * I.

Ceriodaphnia quadrangula (Müller) F.

FAMILY BOSMINIDAE

Bosmina longirostris (Müller) * V.C.

Bosmina longispina Leydig I.

FAMILY MACROTHRICIDAE

Ophryoxus gracilis Sars * I.

Drepanothrix dentata (Eurén) * V.C.

Acantholeberis curvirostris (Müller) * V.C.

Illyocryptus spinifer Herrick * F.

FAMILY CHYDORIDAE

Eurycercus lamellatus (Müller) * F. This species was commonest among weeds in the Pustagone River. Only occasional specimens were taken elsewhere.

Camptocercus rectirostris Schoedler F. This cladoceran, like the species previously mentioned, was local in distribution. A great many specimens were found in a sucker taken at Sandy Bay.

Kurzia latissima (Kurz) * I.

Acroperus harpae Baird * V.C.

Alona guttata Sars * F.

Alona guttata var. *tuberculata* Kurz * I.

Alona affinis (Leydig) * C.

Alona quadrangularis (Müller) * C.

Alona costata Sars * C.

Graptoleberis testudinaria (Fischer) * F. This cladoceran was commonest among weeds in the Pustagone River. Only 2 specimens were taken from the young suckers.

Rhynchotalona falcata (Sars) * V.C. That this is no uncommon species is shown by the fact that 33 out of 56 small suckers had eaten it. The only part of Lake Nipigon in which it was taken was the head of Orient Bay.

Pleuroxus procurvatus Birge * C. This cladoceran was found in the greatest numbers in plankton taken from a small pond near Fairlock on August 31. Elsewhere its occurrence was only occasional.

Pleuroxus denticulatus Birge * V.C.

Pleuroxus hastatus Sars * V.C. This was the species of *Pleuroxus* found most commonly in the stomachs of small suckers.

Chydorus globosus Baird I.

Chydorus sphaericus (Müller) * V.C.

Chydorus faviformis Birge * R. Only 2 individuals of this *Chydorus* were found. One was from a small lake close to the fire ranger tower near Fairlock. The other had been eaten by a young sucker.

Alonella rostrata (Koch) R. One individual was found in a sucker from Sandy Bay.

Alonella nana (Baird) * V.C. This species was of common occurrence both in plankton from among weeds and in suckers from Orient Bay in July and August.

Alonella exigua (Lilljeborg) * C. Numbers of this *Alonella* were found among weeds in a sluggish creek but only one was eaten by the suckers examined.

Monospilus dispar Sars * F. The finding of ten specimens in one sucker would indicate that this species was not particularly rare.

FAMILY POLYPHEMIDAE

Polyphemus pediculus (Linn.) * V.C. This cladoceran was found in small pools and ponds as well as in creeks and bays. Its importance economically is shown by the fact that it had been fed upon by 48 out of 57 small suckers, taken at Orient Bay on July 19. In several instances it was the only species found, and formed the entire contents of the fishes' alimentary tracts.

FAMILY LEPTODORIDAE

Leptodora kindtii (Focke) * V.C. Locally abundant as shown by the examination of cisco stomachs.

In order to give some idea of the abundance of different species of *Cladocera* near the head of Orient Bay the following list of those species taken from three different lots of young suckers may prove useful. Lot A was taken on July 19, and the fishes averaged 2.3 centimetres in length. Lot B was taken on July 27, and the fishes averaged 3.2 centimetres in length. Lot C was taken on August 13, and the fishes averaged 3.8 centimetres in length. The number after the name of each cladoceran listed indicates how many of the fishes out of each lot had eaten that particular species.

Cladocera species	Lot A No. of fish 57	Lot B No. of fish 31	Lot C No. of fish 25
Sida crystallina	40	3	1
Diaphanosoma sp.	6	0	0
Daphnia pulex	13	0	0
Daphnia retrocurva	3	1	0
Daphnia longispina	8	0	1
Scapholeberis mucronata	20	0	0
Ceriodaphnia lacustris	3	0	0
Bosmina longirostris	20	0	20
Ophryoxus gracilis	0	2	0
Drepanothrix dentata	1	26	0
Acantholeberis curvirostris	1	20	0
Illyocryptus spinifer	0	1	11
Eurycercus lamellatus	2	4	1
Kurzia latissima	0	1	1
Acroperus harpae	27	8	0
Alona guttata	1	1	4
Alona guttata tuberculata	0	0	1
Alona costata	9	9	6
Alona quadrangularis	1	11	9
Alona affinis	6	9	13
Graptoleberis testudinaria	0	2	0
Rhynchotalona falcata	1	18	15
Pleuroxus procurvatus	4	0	0
Pleuroxus hastatus	2	23	12
Pleuroxus denticulatus	2	11	18
Chydorus faviformis	0	1	0
Chydorus sphaericus	9	21	18
Alonella nana	0	17	22
Alonella exigua	0	0	1
Monospilus dispar	0	2	10
Polyphemus pediculus	48	2	1
Leptodora kindtii	1	2	1

The greater number of open-water *Cladocera*, such as *Sida* and *Polyphemus*, in the first lot of fishes is due to the fact that, as the sucker gets larger, its mouth becomes more ventrally located and it feeds more upon the ooze and bottom forms of life. The greater numbers of some *Cladocera* in August may be due to an increase of these species in late summer. The average number of species of *Cladocera* taken

from each sucker was 5, but several had eaten 12 and even 13 different species. The greatest number of different species taken from one fish was 14. This was a sucker from Lot B, and the list is as follows:—

Sida crystallina
Drepanothrix dentata
Acantholeberis curvirostris
Ophryoxus gracilis
Bosmina longirostris
Acroperus harpae
Alona quadrangularis
Alona costata
Alona affinis
Pleuroxus hastatus
Pleuroxus denticulatus
Alonella nana
Rhynchotalona falcata
Chydorus sphaericus

The presence of species such as *Sida* and *Bosmina* in bottom feeding fish is probably due to the fish eating dead or disabled individuals which have sunk from the plankton above.

CLASS ARACHNIDA

ORDER HYDRACARINA

Water mites are of considerable importance from the standpoint of fish food, as nearly all of the bottom-feeding fish contained these creatures, although never in numbers comparable with *Cladocera*. The larvae, or six-legged nymphs, were more frequently found than the adults. Those of the genus *Hygrobates* were probably most common, while the genera *Hydrachna* and *Arrhenurus* were found a few times. *Tardigrada* had been eaten by several of the young suckers.

CONCLUSION

This survey of the microscopic fauna and flora of Lake Nipigon formed a part of the larger study of the available

fish food supply in this lake. The general conclusion to be drawn from this qualitative investigation is that Lake Nipigon is a body of water relatively poor in plankton, with the exception of the diatomaceous flora. The number of species occurring in the lake itself was not large, and with a few exceptions the number of individuals of a species was not large. This was particularly true of the open-water plankton. Such important forms as the species of *Daphnia* were uncommon, and apparently *Holopedium* was absent. *Leptodora kindtii* was the only cladoceran which was common in the open water. The *Copepoda* were much better represented in point of numbers, especially in the cases of *Diaptomus* and *Limnocalanus*. In the shallow protected bays, where occurred considerable growths of the higher aquatic vegetation, there was a much better representation of species and larger numbers of individuals. This was especially true of the *Rotatoria* and the *Cladocera*. From the standpoint of food-supply for the young of many species of fish, this is important.

The diatoms were vastly more numerous than all the other organisms combined. They are not directly of much value as fish food, and if of importance as food for the animal planktonts should have supported a much larger population than was found to occur. They may, however, be of considerable importance as food for the macroscopic bottom population, especially *Pontoporeia hoyi*, the larvae of the *Chironomidae* and the *Mollusca*, which are of extreme importance as fish food. The interrelations in the food complex are so involved that it is difficult at the present time to judge accurately the significance of certain organisms or groups of organisms, and it is apparent that studies of the food habits of the lower animals which serve as food for fish must be made before satisfactory conclusions may be arrived at in regard to the evaluation of the various constituents of the plankton.

UNIVERSITY OF TORONTO STUDIES

PUBLICATIONS OF THE
ONTARIO FISHERIES RESEARCH LABORATORY
No. 14

THE DISTRIBUTION AND ECONOMIC IMPORTANCE OF MOLLUSCA IN LAKE NIPIGON

BY

F. B. ADAMSTONE
OF THE DEPARTMENT OF BIOLOGY
UNIVERSITY OF TORONTO

TORONTO
THE UNIVERSITY LIBRARY
1923

THE DISTRIBUTION AND ECONOMIC IMPORTANCE OF MOLLUSCA IN LAKE NIPIGON

The limnobiological investigations carried out in Lake Nipigon during the summer of 1921 involved, amongst other work, a study of the bottom fauna. This was undertaken in order to obtain some knowledge of the species of animals inhabiting the lake bottom and to learn something of their abundance, distribution, and value as fish food. As this phase of the work came largely under the direction of the writer, the methods employed and the results obtained, in so far as they have to do with one group of animals, namely the *Mollusca*, will be given in this paper. For their interest and assistance in the carrying out of this investigation sincere thanks are given to the Honorary Advisory Council for Scientific and Industrial Research.

Methods of Investigation

The method employed in studying the animal life of the bottom was to dredge up samples of the material from the lake floor. For this purpose a small Ekman dredge* which covered an area of 81 square inches, was used. It was lowered open, by means of a small steel cable wound on a windlass, and, when released by a messenger dropped from the boat, its jaws closed upon a sample of the bottom. The material obtained in this manner was hauled up and placed in numbered trays, and data concerning depth, distance from shore, and character of bottom were tabulated in regard to each. Depth was measured directly by a counting machine, over which the cable passed, and distance from shore was estimated as accurately as possible either by judging short distances or by timing the boat. On other

*Dr. C. Juday kindly supplied this dredge.

occasions a drag dredge was used instead of the Ekman dredge. This piece of apparatus consisted of an iron frame to which a sack was attached, and as it was hauled over the bottom it scraped up any loose material with which it came into contact. It was impossible, however, to determine accurately the area of bottom covered by this dredge and it brought up so much material from one spot that the results obtained did not compensate for the time and labour involved in cleaning it. As a result, this dredge was finally abandoned in favour of the Ekman type. At times even the latter could not be used, as, for example, where the bottom was composed of rocks. The dredgings were supplemented by hand collecting along the margin of the lake.

In taking dredgings, a situation was usually chosen where the environmental features made it seem advisable to study the animal population. Then, by beginning in-shore as closely as possible, a series of from 4 to 10 hauls was made, gradually working out into deeper water, along a straight line. The distance between dredgings was governed largely by depth and character of bottom.

The material obtained was taken back to the laboratory and washed through screens of different grades of fineness, so that the loss of smaller organisms was eliminated as much as possible. The cleaned material was carefully sorted while the animals were still alive, and the specimens were preserved in seventy per cent. alcohol in vials.

For the study of the value of bottom organisms as fish food the stomach contents were taken from a large number of fish. This material was sorted over in the laboratory, and the various species of animals in it were identified and their relative importance estimated.

SPECIES OF MOLLUSCA OBTAINED

In the material collected during the summer 44 species of *Mollusca* were identified. Amongst these there are representatives of 8 families and 12 genera. A list of the species obtained is given on the following pages.

GASTROPODA

1. *Lymnaea apicina* Lea.
2. " *emarginata* Say.
3. " *galbana* Say.
4. " *stagnalis appressa* Say.
5. " *vahlii* Moll.

6. *Planorbis antrosus* Con.
" " approaching *corrugatus* Curr.
" " *striatus* Baker.
7. " *crista* L.
8. " *exacuous* Say.
9. " *hirsutus* Gld.
10. " *parvus* Say.
11. " *trivolvis* Say.

12. *Segmentina crassilabris* Walker.

13. *Physa ancillaria* Say.
14. " *gyrina* Say.
15. " sp.
16. " sp.

17. *Ferrissia parallela* Hald.

18. *Amnicola limosa* Say.
" *limosa porata* Say.
19. " sp. possibly *A. pallida* Hald.

20. *Valvata sincera* Say.
21. " *tricarinata* Say.
" " *perconfusa* Walker.

PELECYPODA

22. *Anodonta kennicotti* Lea.
23. " *marginata* Say.

24. *Lampsilis* (*Ligumia*) *superiorensis* Marsh.

25. *Pisidium compressum* Prime. (form of subsp. *pellucidum*).
26. " *fallax* Sterki.

27. *Pisidium idahoense* Roper.
28. " *indianense* Sterki.
29. " *medianum minutum* Sterki.
30. " *monas* Sterki.
31. " *pauperculum* Sterki (near subsp. *nylanderi* Sterki).
32. " *punctatum* Sterki (form *simplex*).
33. " *rotundatum* Prime.
34. " *scutellatum* Sterki.
" " " *cristatum* Sterki.
35. " *splendidulum* Sterki.
36. " *variabile* Prime.
37. " *vexum* Sterki.
38. " *walkeri* Sterki.
39. " sp. (known but not yet published).

40. *Sphaerium crassum* Sterki.
41. " *tenue* Prime.
42. " sp (probably *vermontanum* Prime).
43. *Musculium rosaceum* Prime.
44. " *securis* Prime.

There may be several additional species of *Pisidia*, according to Dr. V. Sterki.

The writer is greatly indebted to Dr. Bryant Walker and Dr. V. Sterki for assistance in the identification of specimens.

TABULATED RESULTS OF DREDGING OPERATIONS

In the following series of tables the results of the dredging operations are given. These show where operations were carried on and give data concerning the molluscan population and environment at each station. Dead specimens are not included in the numbers, but where empty shells were obtained the names have been inserted in the list.

The names of species of *Sphaeriidae* obtained in each locality are noted below each table.

ORIENT BAY AT MACDIARMID

Series II

Dredging	1	2	3	4	5	6	7	8	9
Depth (in feet)	7	45	120	162	93	72	60	12	11
Character of Bottom	Coarse Grit	Grit on Clay	Clay	Mud	Mud	Sand	Rock	Sand	Sand
Distance from Shore (yds.)	10	30	75	175	600	1200	1400	1800	1900
Planorbis antrosus	..	..	..	..	..	..	..	..	3
Planorbis parvus	6	..	..	..	..	..	..	..	..
Amnicola limosa	3	..	..	..	..	..	..	..	1
Amnicola sp.	1	..	..	..	..	..	..	..	..
Valvata sincera	..	..	..	..	..	..	..	2	5
Valvata tricarinata (var.)	..	..	..	..	..	..	..	..	1
Valvata tricarinata	..	..	..	..	..	..	..	3	3
Sphaeriidae	6	..	..	..	..	..	..	6	8

Pisidium compressum
" *pauperculum*
" *scutellatum*
" *variabile*
" sp.

SAND POINT BAY	Series III				SANDY RIVER TO N. SHAKESPEARE			Series IV		
Dredging	1	2	3	4	1	2	3	4	5	6
Depth (in feet)	6	12	21	45	12	21	27	30	48	159
Character of Bottom	Gravel	Gravel	Sand	Mud	Clay	Sand	Sand	Sand	Sand	Mud
Distance from Shore (yds.)	30	60	120	440	150	250	850	1200	2800	4550
Lymnaea galbana	..	..	1	..	..	..	..	..	..	..
Planorbis antrosus	..	2	..	..	..	..	..	..	..	..
Planorbis parvus	1	1	1	..	..	..	..	..	..	..
Amnicola limosa	..	..	..	..	..	1	..	..	..	..
Amnicola sp.	3	..	2	..	..	..	..	..	..	..
Valvata sincera	..	..	..	..	..	..	..	..	2	..
Valvata tricarinata (var.)	..	..	..	..	..	..	..	..	..	..
Valvata tricarinata	1	1	..	..	..	..	..	..	..	..
Physa sp.	..	..	..	..	..	1	..	..	..	..
Planorbis hirsutus	..	..	..	..	..	..	..	..	..	..
Sphaeriidae	1	1	..	..	..	2	..	16	8	..

Pisidium compressum
" *scutellatum*
Sphaerium tenue

SHAKESPEARE ISLAND TO SANDY RIVER

Series V

Dredging	1	2	3	4	5	6	7	8	9	10
Depth (in feet)	150	150	156	163	80	96	78	45	84	192
Character of Bottom	Clay	Clay	Clay	Clay	Clay	Clay	Clay	Gravel	Clay	Mud
Distance from Shore	50 yd.	100 yd	200 yd	400 yd	800 yd	1 mile	2 miles	3 miles	$3\frac{1}{4}$ miles	6 miles
Lymnaea vahlii	..	..	..	..	..	..	..	..	D	..
" *stagnalis*	..	..	..	..	..	..	..	..	D	..
" sp.	..	..	..	..	..	..	..	D	..	..
Segmentina crassilabris	..	..	..	..	..	..	..	D	..	..
Planorbis hirsutus	..	..	..	..	..	..	..	..	D	..
" *parvus*	..	..	..	..	..	..	..	I	..	..
Valvata sincera	..	..	..	..	..	..	D	D	D	..
" *tricarinata*	..	..	..	..	..	..	..	..	D	..
Sphaeriidae	D	D	D	D	D	D	D	7	D	1. D

Pisidium sp.

SAND POINT BAY (OFF McCOLEMAN'S DOCK) Series VI

Dredging	1	2	3	4	5	6	7	8	9
Depth (in feet)	6	9	12	14	15	15	15	15	16
Character of Bottom	Sand	Sand	Sand	Sand & Gravel	Sand & Gravel	Sand & Gravel	Sand & Gravel	Sand & Gravel	Sand & Gravel
Distance from Shore (yd.)	75 ft.	100	150	175	200	225	250	275	300
Lymnaea galbana	..	..	1	..	..	..	..	..	..
" *emarginata*	..	..	..	..	..	..	..	..	..
Planorbis antrosus	..	..	1	1	..	1	..	1	3
Amnicola limosa	..	..	1	..	..	..	..	..	2
" sp.	..	..	..	..	..	..	..	..	3
Valvata sincera	..	..	..	..	1	..	..	1	1
" *tricarinata*	..	..	..	..	1	..	..	1	2
Lymnaea vahlii	..	..	..	..	1	..	..	..	..
Planorbis parvus	..	..	..	..	..	..	..	..	3
Sphaeriidae	..	..	..	..	..	..	..	3	1

Pisidium scutellatum
" sp. juv.
Sphaerium vermontanum

SAND POINT BAY (OFF McCOLEMAN'S DOCK) Series VII

Dredging	10	11	12	13	14	15	16	17
Depth (in feet)	15	21	27	39	53	60	69	75
Character of Bottom	Gravel	Gravel	Mud	Clay	Clay	Mud	Mud	Clay
Distance from Shore (yds.)	330	375	450	600	750	900	1200	1500
Lymnaea galbana	..	..	..	..	..	..	..	..
" *emarginata*	1	..	..	..	..	..	..	..
Planorbis antrosus	3	..	..	..	..	..	..	..
Amnicola limosa	..	..	..	..	..	..	..	..
" sp.	..	..	..	..	..	..	..	..
Valvata sincera	..	..	2	..	..	..	..	..
" *tricarinata*	2	1	..	..	..	..	..	..
Sphaeriidae	..	..	1	..	..	..	..	..

BAY EAST OF COOKE POINT — Series VIII

Dredging	1	2	3	4	5	6	7	8	9	10
Depth (in feet)	15	15	18	21	21	18	23	30	33	48
Character of Bottom	Sand	Sand	Sand	Sand	Gravel	Rock	Sand & Rock	Sand & Rock	Sand & Gravel	Mud
Distance from Shore (yds.)	100	150	200	250	325	400	500	880	1100	1800
Planorbis parvus	..	..	..	..	1	..	..	3	..	..
Amnicola limosa	..	..	..	1	..	5	..	..	..	..
Valvata sincera	..	1	..	..	..	..	..	..	..	..
" *tricarinata*	..	..	..	1	..	..	..	..	..	..
Sphaeriidae	2	2	1	1	..	..	..	..	..	..

Pisidium compressum
Sphaerium vermontanum

BLACKWATER BAY

Series IX

Dredging	1	2	3	4	5	6	7	8
Depth (in feet)	8	9	18	21	21	27	30	33
Character of Bottom	Sand	Sand	Sand	Sand	Sand	Sand	Sand	Sand
Distance from Shore (yds.)	270	300	370	450	525	600	700	880
Lymnaea sp.	..	..	..	..	..	..	..	..
Planorbis parvus	..	..	..	..	..	..	..	..
Amnicola limosa	..	..	..	..	..	1	1	..
Valvata tricarinata (var.)	..	..	..	1	..	..	..	..
" *tricarinata*	..	..	..	..	..	2	..	..
" *sincera*	..	..	..	..	..	2	6	2

Sphaeriidae
Pisidum sp. juv.

BLACKWATER BAY — Series X

Dredging	1	2	3	4	5	6	7	8
Depth (in feet)	12	21	24	27	29	36	39	39
Character of Bottom	Sand	Gravel	Sand	Sand	Sand	Sand	Sand	Sand
Distance from Shore (yds.)	50	100	150	200	300	700	900	900
Lymnaea vahlii	..	..	..	..	..	..	..	1
Planorbis antrosus	..	1	..	..	..	..	..	..
" *parvus*	..	..	..	..	..	2	..	..
Amnicola limosa	..	1	..	..	..	..	..	..
Valvata tricarinata (var.)	..	..	..	..	..	..	..	1
" *sincera*	..	..	..	..	..	1	..	6
" *tricarinata*	..	..	..	..	..	3	..	..
Sphaeriidae	..	2	..	1	..	2	..	1

Pisidium monas
" *medianum minutum*
" *scutellatum*
" sp. juv.

SOUTH SHAKESPEARE ISLANDS

Series XI

Dredging	1	2	3	4	5	6	7	8
Depth (in feet)	3	6	27	48	48	54	51	30
Character of Bottom	Rock	Sand	Clay	Ooze	Ooze	Ooze	Ooze	Ooze
Distance from Shore (yd.)	5	15	80	200	400	600	800	900
Lymnaea vahlii	..	..	..	..	..	..	..	..
Planorbis antrosus	..	1	..	..	..	..	..	..
" *parvus*	..	2	..	..	..	..	..	1
Physa sp.	..	..	..	..	..	..	..	..
Amnicola limosa	1	29	..	..	..	..	..	..
Valvata sincera	..	1	..	..	..	..	..	..
" *tricarinata*	..	..	..	..	..	..	..	..
Sphaeriidae	3	20	..	..	..	..	..	..

Pisidium compressum
" *fallax*
" *pauperculum*
" *scutellatum*
Sphaerium vermontanum (?)

EAST SHAKESPEARE ISLANDS — Series XII

Dredging	1	2	3	4	5	6	7
Depth (in feet)	6	15	21	21	21	18	15
Character of Bottom	Sand among Rocks	Sand	Mud	Algae	Algae	Sand	Sand
Distance from shore (yds.)	15	50	100	200	400	800	1000
Lymnaea emarginata	..	..	..	..	..	..	..
" *galbana*	..	1	..	..	..	..	1
" *vahlii*	..	..	1	..	..	..	..
Planorbis antrosus	..	1	..	..	..	..	1
" *hirsutus*	..	..	..	..	..	..	..
" *parvus*	..	..	1	..	..	..	2
Amnicola limosa	..	5	..	..	..	..	..
" sp.	..	..	..	..	1	1	3
Valvata sincera	..	..	1	5	2	2	3
" *tricarinata*	..	1	1	..	..	..	..
Physa	..	..	1	..	9	1	..
Sphaeriidae	4	7	1	3	..	21	5

Pisidium compressum
" *medianum minutum*
" *scutellatum*
" *splendidulum*
" *variabile*
" sp.

NORTH SHAKESPEARE—HAT MOUNTAIN Series XIII

Dredging	1	2	3	4	5	6	7	8
Depth (in feet)	3	15	18	24	33	57	63	69
Character of Bottom	Sand	Ooze	Mud	Ooze	Gravel & Sand	Mud	Mud	Mud
Distance from shore (yds).	15	80	130	430	530	730	900	1100
Lymnaea galbana	..	..	..	..	..	..	..	..
" *emarginata*	..	..	..	..	..	..	..	..
" *vahlii*	..	..	..	..	..	..	..	..
Planorbis antrosus	..	..	..	1	..	..	..	..
" *parvus*	..	3	3	3	..	..	..	..
Physa	..	..	..	..	..	..	..	..
Amnicola limosa	..	..	..	..	..	..	..	..
" sp.	..	3	..	5	..	..	..	..
Valvata sincera	..	5	7	5	..	..	..	..
" *tricarinata*	..	1	..	1	..	..	..	..
Sphaeriidae	..	6	5	14	1	1	..	..

Pisidium compressum
" *medianum minutum*
" *pauperculum*
" *scutellatum*
" *splendidulum*
" *variabile*

McL. BAY

Series XIV

Dredging	1	2	3	4	5	6	7	8
Depth (in feet)	3	3	6	6	9	15	30	36
Character of Bottom	Wood, Debris, & Mud	Mud	Mud	Mud	Mud	Mud	Sand	Clay
Distance from Shore (yds)	15	40	75	150	200	250	350	450
Lymnaea galbana	..	..	..	..	..	..	..	..
" *vahlii*	..	..	..	1	..	..	..	..
" sp.	..	..	..	..	..	..	..	..
Planorbis parvus	1	..	2	1	2	..	..	..
" *antrosus*	1	1	2	1	3	..	..	..
Segmentina crassilabris	..	..	..	..	..	..	..	..
Amnicola limosa	..	1	1	..	13	..	..	..
" sp.	..	3	14	7	39	..	..	..
Valvata sincera	..	..	6	2	6	..	..	..
" *tricarinata*	1	..	..	1	4	..	..	..
Sphaeriidae	1	2	8	2	18	2	..	..

Pisidium compressum
" *pauperculum*
" *scutellatum*
" *variabile*
" *walkeri*

FOOT OF ORIENT BAY — Series XV

Dredging	1	2	3	4	5	6	7	8	9	10
Depth (in feet)	12	3	2	5	3	5	9	69	51	27
Character of Bottom	Gravel	Sand	Sand	Sand	Sand	Sand	Sand	Mud	Mud	Mud
Distance from Shore (yds.)	..	100	200	300	400	550	700	800	900	1000
Lymnaea galbana	..	..	..	1	1	..	..	..	..	..
Planorbis antrosus	..	..	..	..	2	1	..	..	..	..
Segmentina crassilabris	..	..	..	..	..	..	2	..	..	..
Planorbis hirsutus	..	..	..	3	1	5	..	..	..	..
" *parvus*	..	..	..	2	1	1	..	..	..	..
Amnicola limosa	..	..	..	3	2	1	..	..	..	..
" sp.	1	..	..	1	2	..	16	..	..	..
Valvata sincera	..	..	..	..	..	..	2	..	..	..
" *tricarinata*	..	..	..	..	..	1	2	..	..	..
Sphaeriidae	2	..	..	3	..	..	5	5	..	13

Pisidium scutellatum
" sp. juv.
Musculium roseceum
" *securis*

BLACKWATER BAY — Series XVI

Dredging	1	2	3	4	5	6	7	8	9
Depth (in feet)	12	21	21	21	39	90	117	147	178
Character of Bottom	Sand	Mud & Gravel	Mud & Gravel	Mud & Gravel	Mud	Clay	Mud	Mud	Mud
Distance from Shore (yds.)	50	150	250	350	450	550	650	750	1000
Planorbis parvus	..	..	..	..	1	..	..	..	..
Amnicola limosa	..	..	..	..	1	..	..	..	..
" sp.	..	..	..	2	..	..	..	..	..
Valvata sincera	..	..	..	..	4	..	..	..	..
" *tricarinata* (var.)	..	..	..	1	..	..	..	..	..
" *tricarinata*	..	..	..	..	1	..	..	..	..
Sphaeriidae	..	1	..	1	..	2	..	..	..

Pisidium sp. juv.
Sphaerium sp.

SECOND CHANNEL W. OF NIPIGON RIVER — Series XVII

Dredging	1	2	3	4	5	6	7	8	9
Depth (in feet)	18	18	12	12	12	3	27	28	..
Character of Bottom	Mud	Mud	Mud	Mud	Mud	Sand	Gravel	Mud & Sand	..
Distance from Shore (yds.)	25	75	150	250	350	550	750	1150	..
Lymnaea vahlii	..	..	..	..	..	..	..	..	..
Planorbis antrosus	..	..	..	..	3	..	2	..	..
" *parvus*	..	..	1	2	..	2	1	..	..
Physa	..	..	..	..	..	..	..	..	..
Amnicola limosa	3	4	2	7	2	..	5	..	..
" sp.	..	3	3	1	4	3	13	..	..
Valvata sincera	1	4	5	..	..	2	2	..	..
" *tricarinata* (var.)	..	..	1	..	4	..	4	..	..
" *tricarinata*	1	..	..	2	..	..	..	..	..
Sphaeriidae	..	1	7	14	2	..	6	1	..

Pisidium compressum
" *pauperculum*
" *scutellatum*
" *variabile*
" sp. (known, not published)
" sp. juv.
Musculium sp.

SOUTH BAY (WEST SHORE)

	Series XVIII				SOUTH BAY (WEST SHORE) Series XIX			
Dredging	1	2	3	4	1	2	3	4
Depth (in feet)	1½	3	6	6	2	4	5	5
Character of Bottom	Sand	Sand	Mud & Gravel	Mud & Gravel	Mud & Sand	Mud	Mud	Mud
Distance from Shore (yds.)	25	50	75	200	15	25	40	65
Lymnaea galbana	..	..	1	..	7	..	..	..
Planorbis antrosus	..	..	1	..	..	..	..	..
" *parvus*	..	..	1	..	1	..	..	..
Amnicola limosa	..	..	..	..	..	2	3	.
" sp.	..	..	11	3	..	1	5	..
Valvata sincera	..	..	4	..	..	..	..	..
" *tricarinata*	..	..	1	..	..	..	1	..
Physa gyrina	..	..	..	..	..	..	..	..
Lymnaea emarginata	..	..	..	..	..	..	..	..
Sphaeriidae	..	..	5	7	37	12	15	6

Pisidium compressum
" *pauperculum*
" *scutellatum*
" *variabile*

Pisidium compressum
" *medianum minutum*
" *pauperculum*
" *scutellatum*
" *variabile*
" sp.
" sp.
Sphaerium tenue

SECOND BAY WEST OF NIPIGON RIVER

Series XX

Dredging	1	2	3	4	5	6	7	8	9
Depth (in feet)	5	18	18	33	33	33	12	6	5
Character of Bottom	Mud	Mud	Mud	Mud	Mud	Mud	Mud	Mud	Mud
Distance from Shore (yds.)	15	50	150	250	300	350	400	450	550
Lymnaea galbana	..	..	..	..	..	..	..	..	..
" *vahlii*	..	..	..	..	..	..	1	..	..
" sp.	..	..	..	..	..	..	..	..	..
Planorbis antrosus	..	..	..	..	..	..	..	..	..
" *hirsutus*	..	..	..	..	..	..	..	..	..
" *parvus*	2	..	..	..	..	..	..	1	..
Amnicola limosa	1	..	1	..	..	..	3	2	..
" sp.	2	1	..	..	..	..	4	8	..
Valvata sincera	1	..	..	..	..	..	2	..	..
" *tricarinata*	..	1	..	..	..	..	..	..	..
Sphaeriidae	17	..	1	..	..	..	1	3	..

Pisidium scutellatum
" *vexum*
" *variabile*
" sp. juv.

BEAR CREEK — Series XXI

	1	2	3	4	5	6
Dredging						
Depth (in feet)	18	9	9	9	9	9
Character of Bottom	Mud	Mud & Debris	Sand & Debris	Sand	Sand	Sand
Distance from Shore (yds.)	20	300	600	900	1300	1700
Segmentina crassilabris	..	..	..	..	..	.
Planorbis exacuous	..	..	..	..	..	..
" *parvus*	..	..	..	..	..	..
Amnicola limosa	..	..	..	..	..	..
" sp.	..	..	..	..	..	..
Valvata sincera	..	..	..	..	..	..
" *tricarinata*	..	..	..	..	..	..
Sphaeriidae	1	2	..	..	..	1

Pisidium variabile
Musculium juv. (apparently *rosaceum*)
Sphaerium sp. juv.

NORTH SHAKESPEARE BAY — Series XXII

Dredging	1	2	3	4	5	6	7	8	9
Depth (in feet)	4	18	18	36	24	15	9	6	2½
Character of Bottom	Mud	Mud	Mud & Gravel	Mud	Mud	Mud	Mud	Sand	Sand
Distance from Shore (yds.)	10	60	110	210	610	710	760	810	840
Lymnaea galbana	..	..	..	..	..	..	..	..	..
" *vahlii*	1	..	..	..	..	..	..	..	..
Planorbis antrosus	2	..	..	..	..	..	..	..	..
" *hirsutus*	4	..	..	..	..	..	..	..	..
" *parvus*	..	..	..	..	..	1	..	..	..
Amnicola limosa	8	..	..	..	..	1	2	20	..
" sp.	14	..	1	..	..	..	1	11	..
Valvata sincera	3	3	..	..	..	..	..	..	..
" *tricarinata*	1	..	1	..	..	..	2	1	..
Sphaeriidae	14	2	..	6	..	1	3	4	..

Pisidium pauperculum
" *punctatum* (f. *simplex*)
" *scutellatum cristatum*
" *variabile*
" sp. juv.
Sphaerium crassum
" sp. juv.

NORTH SHAKESPEARE ISLANDS — Series XXIII

	1	2	3	4	55	6	7	8
Dredging								
Depth (in feet)	5	17	21	21	15	9	42	42
Character of Bottom	Gravel among Rocks	Sand	Sand	Sand	Sand	Sand	Mud	Mud
Distance from Shore (yds.)	10	40	40	60	100	130	230	380
Lymnaea galbana	1	1	..	..	..	..	..	..
" *vahlii*	..	..	..	..	..	..	..	..
Planorbis antrosus	..	..	..	..	..	3	..	..
" *parvus*	..	..	..	..	..	7	..	..
Segmentina crassilabris	..	..	..	..	..	..	..	..
Physa	..	..	..	..	..	1	..	..
Amnicola limosa	..	..	..	..	..	11	..	..
" sp.	..	1	..	..	..	12	..	..
Valvata sincera	1	..	1	..	..	6	..	..
" *tricarinata*	..	1	..	..	..	5	..	..
Sphaeriidae	..	12	..	..	..	15	..	3

Pisidium compressum
" *pauperculum*
" *rotundatum*
" *scutellatum*
" *variabile*
" sp.
Sphaerium tenue
" *vermontanum* (?)

ORIENT BAY (AT MACDIARMID)

Series XXIV

Dredging	1	2	3	4	5	6	7	8	9
Depth (in feet)	6	39	90	150	87	69	63	11	9
Character of Bottom	Sand	Mud	Mud	Mud	Mud	Mud	Clay	Sand & Clay	Mud
Distance from Shore (yds.)	10	30	60	160	800	1000	1100	1500	1700
Lymnaea galbana	..	..	..	..	..	..	..	..	..
" *vahlii*	..	..	..	..	..	..	..	..	1
Planorbis antrosus	..	..	..	..	..	..	..	..	1
" *parvus*	1	..	..	..	..	..	..	..	..
Segmentina crassilabris	..	..	..	..	..	..	..	..	..
Amnicola limosa	2	..	..	..	..	..	..	..	1
" sp.	1	..	..	..	..	..	1	4	2
Valvata sincera	1	1	..	..	..	..	..	4	..
" *tricarinata*	..	..	..	..	..	..	..	1	..
Sphaeriidae	4	1	..	..	..	2	4	7	2

Pisidium compressum
" *monas*
" sp. juv.
Sphaerium sp. juv.

NAONAN IDS.	NIPIGON HOUSE			MACDIARMID HARBOUR		
	Series I	Series VII		Series XXV		
Dredging	1	1	2	1	2	3
Depth (in feet)	150 (?)	144	36 (?)	9	8	5
Character of Bottom	Mud & Shells	Clay	Mud	Mud	Mud	Mud
Distance from Shore (yds.)	800	800	125	100	75	25
Lymnaea galbana	..	..	..	1	..	..
" *emarginata*	..	..	..	1	..	1
Planorbis antrosus	..	..	..	11	..	..
" *parvus*	..	..	..	2	..	..
Amnicola limosa	..	..	1	2	..	..
" sp.	..	..	..	2	..	..
Valvata sincera	..	..	2	3	..	..
" *tricarinata*	..	..	..	..	..	..
Physa gyrina	..	..	..	..	3	1
Sphaeriidae	..	..	..	15	..	..

Pisidium compressum
" *pauperculum*
" *punctatum* (f. *simplex*)
" *variabile*
" sp.?

ORIENT BAY and NORTHWARD—EAST SHORE — Series XXVI

Dredging	1	2	3	4	5	6	7	8	9
Depth (in feet)	9	18	8	12	18	24	27	48	129
Character of Bottom	Sand	Sand	Sand	Sand	Gravel	Sand	Sand	Sand	Mud
Distance from Shore (yds.)	30	60	85	130	230	280	330	380	430
Lymnaea vahlii	..	..	..	..	..	..	..	..	..
Planorbis antrosus	..	..	..	..	..	..	..	..	..
" *exacuous*	..	..	..	..	..	..	..	..	..
" *parvus*	..	..	..	..	..	..	..	1	..
Physa gyrina	..	..	..	..	..	..	..	..	..
Amnicola limosa	2	4	..	..	..	..	..	..	..
" sp.	2	..	..	..	..	..	..	..	..
Valvata sincera	1	..	..	..	..	..	1	..	..
" *tricarinata* (var.)	1	1	..	..	..	..	..	..	..
Sphaeriidae	2	1	1	..	..	..	..	3	..

Pisidium compressum
" *pauperculum*
" sp. juv.
Sphaerium sp. juv.

VIRGIN ISLANDS — Series XXVII

Dredging	1	2	3	4	5	6	7	8	9
Depth (in feet)	6	12	15	150	15	12	9	5	3
Character of Bottom	Sand	Sand	Sand	Sand	Sand	Mud & Sand	Mud & Sand	Mud & Sand	Mud
Distance from Shore (yds.)	10	50	100	150	200	300	400	500	600
Lymnaea emarginata	1	..	..	..	..	..	..	..	..
" *galbana*	..	..	..	1	..	..	..	1	..
" *vahlii*	..	..	..	..	..	..	..	1	..
Planorbis antrosus	18	..	..	..	..	..	..	1	6
" *hirsutus*	..	..	..	..	..	..	..	..	..
" *parvus*	..	1	..	..	3	..	..	3	7
Amnicola limosa	16	2	..	1	..	..	2	9	48
" sp.	11	..	..	..	3	1	5	7	62
Valvata sincera	..	1	..	..	3	3	1	..	..
" *tricarinata*	9	1	..	..	1	1	1	..	17
Sphaeriidae	41	9	..	1	..	7	1	9	3

Pisidium compressum
" *indianense*
" *pauperculum*
" *scutellatum*
" *variabile*
" sp.?
" sp ?

McINTYRE BAY (SOUTH END) Series XXVIII

Dredging	1	2	3	4	5	6		8	9
Depth (in feet)	1	3	9	12	15	18	21	24	24
Character of Bottom	Sand	Mud on Sand	Mud & Gravel	Mud & Sand	Mud & Sand	Mud	Mud	Mud	Mud
Distance from Shore (yds.)	23	75	125	175	225	325	425	525	625
Lymnaea galbana	..	..	..	..	..	1	1	..	..
Planorbis antrosus	..	..	..	1	1	1	..	..	..
" *hirsutus*	..	..	2	3	1	..	..	..	..
" *parvus*	..	..	..	1	2	..	1	1	..
Amnicola limosa	..	..	2	..	..	..	..	1	..
" sp.	..	..	4	2	1	1	..	..	1
Valvata sincera	..	..	1	1	..	..	2	..	4
" *tricarinata* (var.)	..	..	..	..	1	1	..	..	..
" *tricarinata*	..	..	1	..	..	..	..	..	1
Sphaeriidae	4	1	7	4	..	2	2	1	2

Pisidium compressum
" *medianum minutum*
" *monas*
" *pauperculum*
" sp.?
" sp.?
Sphaerium vermontanum

McINTYRE BAY (EAST SIDE AMONG ISLANDS) Series XXIX

Dredging	1	2	3	4	5	6	7	8
Depth (in feet)	3	6	12	18	18	21	21	15
Character of Bottom	Mud	Mud	Mud	Mud	Mud	Mud	Mud	Mud
Distance from Shore (yds.)	10	60	110	160	210	260	310	360
Planorbis antrosus	..	..	..	..	..	..	..	..
" *parvus*	..	..	..	..	..	..	..	..
Amnicola limosa	..	..	..	..	..	..	..	5
" sp.	4	4	..	1	..	1	..	..
Valvata sincera	..	1	..	..	..	..	..	..
" *tricarinata* (var.)	..	..	2	..	..	..	..	1
" *tricarinata*	..	..	..	..	2	2	..	..
Sphaeriidae	12	3	1	2	4	7	5	3

Pisidium compressum
" *medianium minutum*
" *pauperculum*
" *punctatum*
" *scutellatum cristatum*
" *variabile*
" sp.?
Sphaerium vermontanum

McINTYRE BAY (NORTH END)

Series XXX

Dredging	1	2	3	4	5	6
Depth (in feet)	6	9	9	21	45	48
Character of Bottom	Mud	Mud	Mud	Mud	Mud	Mud
Distance from Shore (yds.)	30	80	130	180	230	280
Planorbis trivolvis	..	..	..	..	..	..
" *hirsutus*	..	..	2	..	..	..
" *parvus*	..	..	1	1	2	..
Amnicola limosa	24	2	1	..	..	..
" sp.	20	14	4	..	..	..
Valvata sincera	..	..	..	..	..	..
" *tricarinata* (var.)	..	1	1	1	..	..
Sphaeriidae	3	..	..	..	..	..

Pisidium variabile
" sp.?

GROS CAP	Series XXXI					ALEXANDER ID. Series XXXII			
Dredging	1	2	3	4	5	1	2	3	4
Depth (in feet)	3	9	15	24	30	1	4	6	9
Character of Bottom	Mud	Mud	Mud	Mud	Mud	Mud	Sand	Sand	Sand
Distance from Shore (yds.)	10	35	60	110	210	10	25	50	100
Lymnaea vahlii	..	..	.	..	..	..	..	1	1
" *galbana*	..	..	..	..	..	..	5	14	..
Segmentina crassilabris	..	..	..	..	..	..	..	..	..
Planorbis antrosus	..	..	..	..	..	..	..	2	..
" *hirsutus*	..	..	1	..	..	..	..	..	..
" *parvus*	4	3	..	..	..	1	2	12	1
Amnicola limosa	3	19	..	..	..	..	..	6	2
" sp.	15	8	..	3	..	..	..	..	..
Valvata sincera	1	..	1	1	..	1	1	..	1
" *tricarinata* (var.)	..	5	..	..	..	..	2	1	..
" *tricarinata*	..	..	2	..	..	..	..	..	..
Sphaeriidae	15	3	1	1	..	1	40	16	15

Pisidium medianium minutum
" *pauperculum*
" *splendidulum*
" *variabile*
Sphaerium vermontanum

Pisidium compressum
" *idahoense*
" *medianum minutum*
" *pauperculum*
" *scutellatum*
" *variabile*
" sp.?
" sp.?

Map of the southeastern portion of Lake Nipigon showing the localities where dredgings were taken and the character of the shore line. *Shore:* dots indicate rock; lines indicate sand. *Bottom:* +=mud; •=sand; ν=clay; △=rock; •/ν=sand on clay.

In the foregoing series of tables the results of all dredging operations are given. These were supplemented by a large number of shore collections. In all, some 235 samples were obtained with the dredge. Each sample represented an area of 81 square inches, and in the results that area is taken as a unit. The largest number of dredgings were made in water down to 21 feet in depth, a total of 144 having been secured in this range. The greatest depth from which specimens were brought up was 192 ft. In the detailed consideration of the *Mollusca*, no account is taken of dead specimens, but a very large number of them were obtained.

Distribution of Species

Study of the data obtained makes it evident that, as regards distribution, the species of *Mollusca* form two distinct groups:

1. Species inhabiting very shallow water close to shore.
2. Species inhabiting deeper water at some distance from shore.

The first group includes the various species of *Lymnaea*, *Physa*, and all but two of the species of *Planorbis*. Specimens of these were generally obtained in shore collections, and were nearly always found in rocky situations or in restricted areas having some peculiar environmental features. In most cases the species involved did not have a very general distribution, but, taken as a whole, the group cannot be neglected. The following table gives the species of this division, as well as their habitats.

The peculiar localization of some species is well illustrated by the two species *Planorbis trivolvis* and *Planorbis crista*. Each was found in only one situation where conditions were favourable. The former was obtained in a quiet, well-sheltered harbour at the north end of Alexander Island where the water was very calm. Here the species was very abundant because the environment was quite suitable to its fragile shell. The other species, *Planorbis crista*, was found in a small bay at the south end of the lake. Large numbers

of the minute spiny shells occurred on stones in very shallow water close to shore. Of the other members of the group, some were found in protected shallow bays, but the majority of them inhabited rocky, exposed shores, often where they were scarcely covered with water.

Species	Character of Bottom	Remarks
Lymnaea apicina	Rock	Exposed shores, water 1-3 ft. deep.
" *emarginata*	"	" "
" *galbana*		
" *stagnalis* (var.)	Rock, Sand, Mud	Common in water, 1-12 ft. deep.
" *vahlii*		
Planorbis crista	Rock	Limited to one locality—very shallow water.
" *exacuous*	"	Common in shallow water only.
" *hirsutus*	"	Frequent in shallow water.
" *trivolvis*	Mud	Limited to one locality—water 4 ft. deep.
Physa ancillaria	Rock	Exposed shores.
" *gyrina*	"	" "
" sp. (1)	"	Taken only in Pustagone River.
" sp. (2)	"	" " " " "
Segmentina crassilabris	Mud	Rare.
Ferrissia parallela	Rock	In streams.

The species included in the second group, which is composed of forms inhabiting deeper water, are much more abundant and widely distributed. Consequently, they will be considered in more detail.

Genus Amnicola

The two species of *Amnicola* were obtained in the dredging operations in considerable numbers. From the data secured in this manner the following table has been prepared to show the distribution according to depth and character of bottom. The averages given were obtained by dividing the number of specimens from any particular depth by the total number of dredgings for that depth and for the kind of bottom

considered. Intervals of three feet were taken because the counting machine, which registered depth, gave the distance in yards, and, as fractions had to be estimated, personal error resulted in most of them coming near an even number of yards.

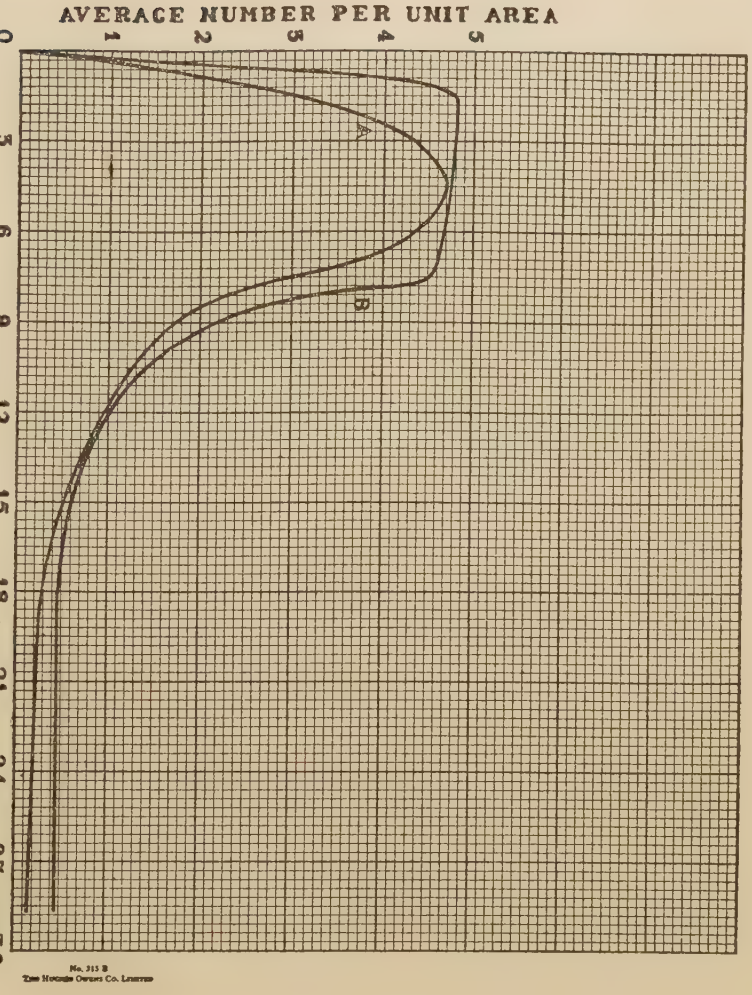
Depth.	*Amnicola limosa*						*Amnicola* sp.					
	Mud		Sand				Mud		Sand			
	No.	Av.	No.	Av.	Total	Av.	No.	Av.	No.	Av.	Total	Av.
0-3	52	6.50	3	.33	55	3.05	84	10.5	5	.55	89	4.94
3-6	50	3.33	77	6.42	127	4.70	96	6.4	27	2.25	123	4.55
9	44	4.9	17	1.42	64	3.05	69	7.7	31	2.6	100	4.76
12	14	1.55	4	.40	18	.90	15	1.7	1	1.0	16	.80
15	6	1.0	6	.43	12	.60	4	.66	6	.43	18	.90
18	8	.72	11	1.57	18	1.0	7	.64	5	.70	12	.66
21	0	0	3	.30	3	.15	4	.50	2	.20	6	.30
24	1	.2	0	0	1	.12	6	1.2	0	0	6	.75
27	0	0	6	1.2	6	.75	0	0	10	2.00	10	1.2
30	0	0	1	.2	1	.12	2	.66	0	0	2	.25

From the results given in the preceding table, curves have been drawn (Graph 1), which illustrate the distribution of these species according to depth. A study of these curves shows that, whereas the optimum depth for *Amnicola limosa* (and its variety) is between 0-9 ft., the other species reaches a maximum between 3-6 ft. Both species, however, are about equally abundant at their optimum depth.

The table brings out another peculiar feature, in that both species are most abundant at a depth between 0-3 ft. on mud bottoms, and at a depth between 3-6 ft. on sand bottoms.

Genus Valvata

Two species of *Valvata*, namely, *Valvata sincera* and *Valvata tricarinata*, were fairly common. In working out the distribution according to depth, the last species and its variety are considered together because of their similarity



GRAPH I. Curves illustrating distribution according to depth. A. *Amnicola limosa*; B. *Amnicola* sp.

and because the total number of specimens was not very great.

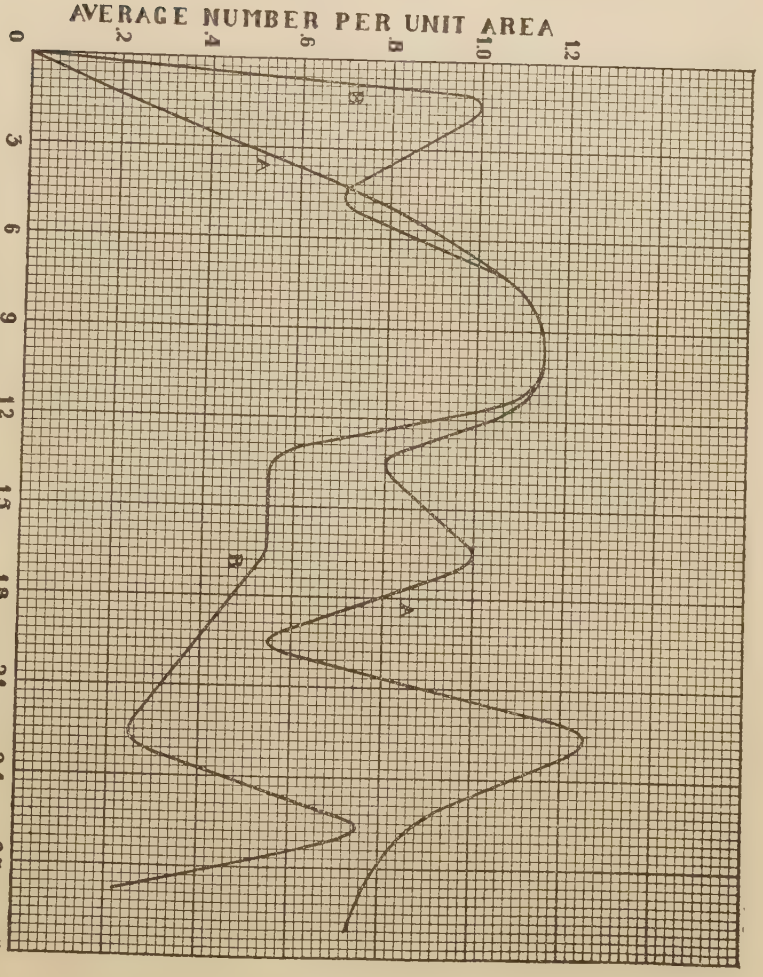
Depth	*Valvata sincera*						*Valvata tricarinata*					
	Mud		Sand				Mud		Sand			
	No.	Av.	No.	Av.	Total	Av.	No.	Av.	No.	Av.	No.	Av.
0-3	2	.25	2	.22	4	.22	18	2.25	0	0	18	1.00
3-6	17	1.13	4	.33	21	.74	4	.27	15	1.25	19	1.70
9	13	1.44	10	.83	23	1.09	15	1.66	8	.66	23	1.09
12	11	1.22	12	1.20	23	1.15	10	1.11	13	1.30	23	.15
15	6	1.00	10	.71	16	.80	5	.83	6	.43	11	.55
18	15	1.36	3	.43	18	1.0	6	.55	4	.57	10	.55
21	10	1.25	1	.10	11	.55	5	.62	3	.30	8	.40
24	10	2.0	0	0	10	1.25	2	.40	0	0	2	.25
27	2	1.0	5	1.0	7	.87	4	2.0	2	.40	6	.75
30	0	.0	6	1.20	6	.75	0	0	0	0	0	0
33	0	0	2	.66	2	.33	0	0	0	0	0	0
36	2	1.0	1	1.0	3	.75	0	0	3	3.0	3	.75
39	5	1.66	6	3.0	11	1.83	1	.33	1	.5	2	.33

The curves (Graph 2), obtained from the data given in the above table, are both very irregular. This indicates, in all probability, that the two species are distributed fairly uniformly over a large range of depths. There is, however, a difference between the two in that *Valvata tricarinata* becomes quite abundant between depths of 0-3 ft. but *Valvata sincera* does not reach a maximum until a depth between 6-9 ft. is reached.

If the averages are taken into consideration, both species are apparently more abundant on mud than on sand bottoms.

Genus Planorbis

Two species of the genus *Planorbis*, namely, *Planorbis antrosus* and *Planorbis parvus*, extend out into fairly deep waters. A table showing the relation of the abundance of these two species to depth is given below.



GRAPH II. Curves illustrating distribution according to depth. A. *Valvata sincera*; B. *Valvata tricarinata*.

Depth	*Planorbis antrosus*				*Planorbis parvus*			
	Mud	Sand			Mud	Sand		
	No.	No.	Total	Av.	No.	No.	Total	Av.
0-3	8	2	10	.55	14	3	17	.88
3-6	7	22	29	1.07	10	21	31	1.15
9	15	3	18	.86	8	14	22	1.05
12	4	6	10	.50	4	2	6	.30
15	1	8	9	.45	6	5	11	.55
18	1	3	4	.22	3	1	3	.33
21	0	1	1	.05	33	2	5	.25
24	1	0	1	.12	4	0	4	.50
27	0	2	2	.24	0	1	1	.12
30	..	..	..	..	1	3	4	.50

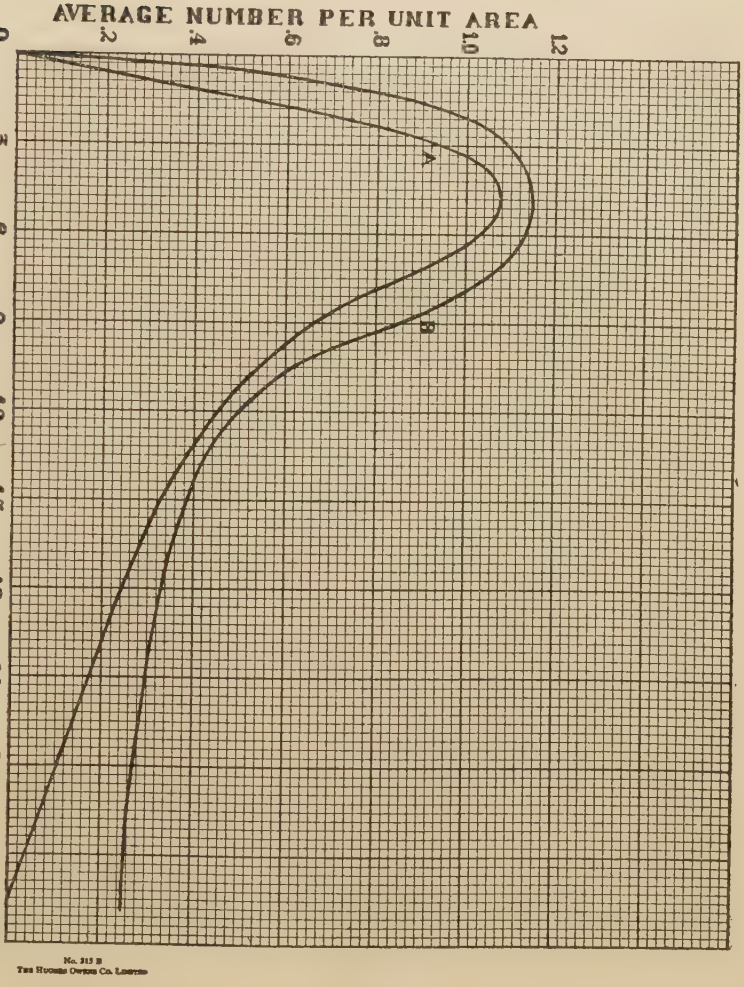
Curves drawn (Graph 3), by using the data given in the table, show that both *Planorbis antrosus* and *Planorbis parvus* reach a maximum in a depth between 3-6 ft. *P. antrosus* and its varieties do not extend beyond a depth of 27 ft. but the other species goes on out into much deeper water, some having been taken from a depth of 45 ft.

Family Sphaeriidae

The species belonging to this family have all been grouped together in drawing up tables showing their relation to depth. This was done because there were only a few specimens of some species, and also because, in general, the species seem to live under similar environmental conditions. The summarized results are given in the following table.

A graph has also been drawn (Graph 4), by using the averages given in this table, to show the distribution of the *Sphaeriidae* with depth. From this it is apparent that the optimum depth is between 3-6 ft., although they extend, in fair numbers, into depths of over 30 ft. Some specimens were also obtained at a depth of 192 ft.

A consideration of all the curves shows that the optimum depth for most species of *Mollusca* inhabiting deep water is from 3-6 ft., but, in the range of depths between 0-12 ft.,



GRAPH III. Curves illustrating distribution according to depth. A. *Planorbis antrosus*; B. *Planorbis parvus*.

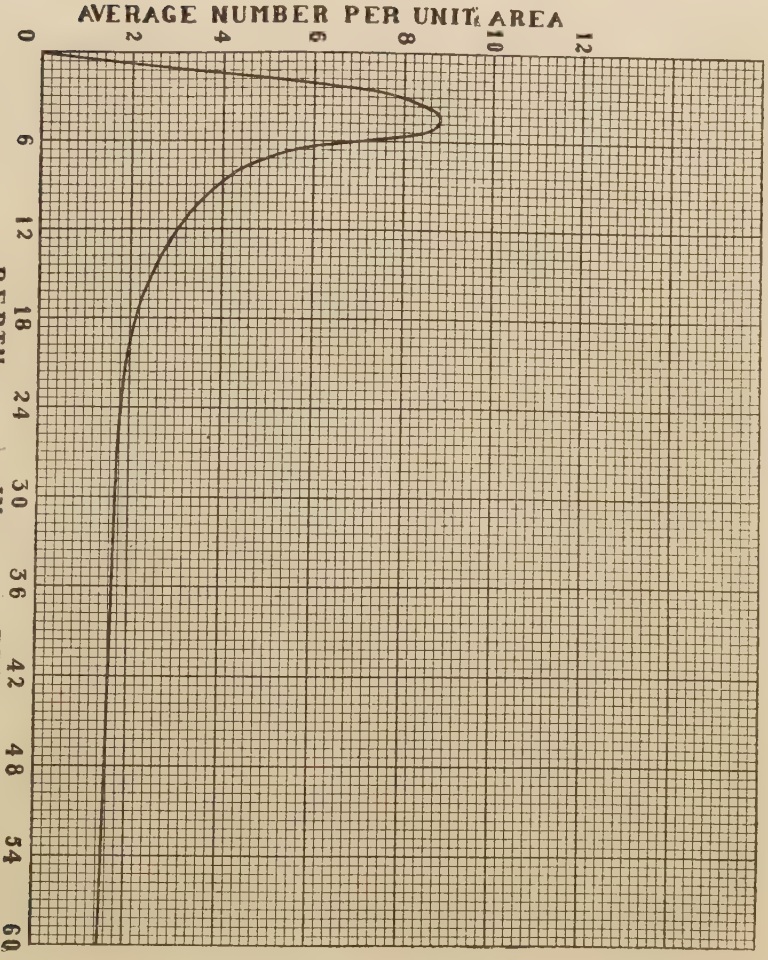
	Sphaeriidae					*Sphaeriidae*			
	Mud	Sand				Mud	Sand		
Depth	No.	No.	Total	Av.	Depth	No.	No.	Total	Av.
0-3	72	7	79	4.39	36	6	2	8	2.0
3-6	104	133	237	8.85	39	1	1	2	.33
9	61	45	96	4.57	42	3	0	3	1.50
12	36	30	66	3.30	45	0	7	7	1.75
15	13	20	33	1.65	48	0	11	11	1.83
18	18	37	55	3.05	57	..	..	1	..
21	20	5	25	1.25	63	..	..	4	..
24	18	0	18	2.25	69	..	..	7	..
27	14	7	21	2.62	90	..	..	2	..
30	1	16	17	2.12	117	..	..	2	..
33	0	2	2	.33	192	..	..	1	..

there is nearly always a fairly large number of them. Moreover, of the various species obtained in dredgings, *Amnicola limosa* and *Amnicola sp.* are by far the most numerous.

The remainder of the *Mollusca*, *i.e.*, the larger *Pelecypoda*, were quite scarce throughout the whole of the southern end of the lake. They were obtained in only a few restricted areas in fairly shallow water, and in situations where there was ample protection from wave action. Such conditions were found at the ends of long narrow bays or in the channels between islands, and only in such locations were large bivalves obtained, as the following table shows.

Species	Where found
Anodonta kennicotti	Shakespeare Islands, Channel West of Nipigon River. Orient Bay, Virgin Islands.
Anodonta marginata	Shakespeare Islands, Channel West of Nipigon River. Virgin Islands.
Lampsilis (Ligumia) superiorensis	Pustagone River.

Because of the great scarcity of these animals in the south end of the lake it was not thought advisable to make any estimate of their numerical abundance. The work done by



GRAPH IV. Curve illustrating distribution according to depth. *Sphaeriidae.*

Muttkowski (1918) shows a similar rarity of the larger *Pelecypoda* in Lake Mendota, although there was an abundance of the small *Sphaeriidae*. This is almost identical with conditions in Lake Nipigon.

The reason for the infrequent occurrence of these forms in Lake Nipigon is doubtless due to the fact that areas, furnishing a suitable habitat, where there is quiet water and an abundance of food material as well as the proper kind of bottom, are very restricted.

Environmental Factors Limiting Distribution

A consideration of the habitats of the various species of *Mollusca* shows that the ecological features, which might have a bearing on the distribution of these animals, are: abundance of food, temperature, chemical content of the water, depth, character of bottom, and protection from wave action. Temperature would not appear to be a limiting factor in the distribution of the species occurring in Lake Nipigon, since all the species are subjected to a temperature at least as low as 4° C. during a large portion of the year, and up to the present no species has been found to occur only in the cold waters of the lake. Temperature, however, may be an indirect factor in view of the fact that, in depths of less than 30 feet, all species have their maximum numbers, and this is the zone of highest temperatures.

The amount of oxygen in the water was seemingly of no significance, for there was no deficiency in the amount of dissolved oxygen at any depth during this season. The amount of carbon dioxide dissolved in the water was very small during this season, and would not therefore be a factor either.

Depth of water is, of course, a feature which indirectly, at least, has to do with the distribution of *Mollusca*. This has been amply demonstrated (1) in the division of *Mollusca* into the two groups of shore and deep water forms, a grouping having its basis largely, no doubt, on the differences in the respiratory system, and (2) in the variation of the optimum depth for the various species.

The character of the bottom also influences the abundance of *Mollusca*. This is evident in the fact that the shore forms are nearly always found among rocks, while those inhabiting deeper water prefer mud or sand. Furthermore, as the consideration of the *Amnicolas* showed, the optimum depth may vary with the bottom according to the species.

Protection from wave action and abundance of food would seem to be the most important factors which influence the distribution of *Mollusca*. The shore forms have a good supply of food in the filamentous algae on the rocks, and when violent storms come up they are able to retreat into crevices amongst the boulders. Their shells are, moreover, solid enough to withstand moderate wave action, and as a result they are found in large numbers on more exposed parts of the shore. The species inhabiting deeper water appear to choose, uniformly, sheltered locations in which an ample supply of food material is available on the bottom. This is shown by the fact that dredgings taken in exposed places or where the bottom was composed of clean sand were nearly always poor in animal life, not only in regard to *Mollusca* but in regard to other forms as well.

VALUE OF MOLLUSCA AS FISH FOOD

The number of species of fish found in Lake Nipigon during the past season was not large. In all only about 25 or possibly 26 species were obtained, and nearly half of these were small forms such as sticklebacks, darters, minnows, etc. As a result the number of species which might feed on *Mollusca* was correspondingly limited and, in fact, only five were found to contain them. From the work done with a view to finding out the extent to which *Mollusca* are taken as food by fish, the following summary of the results obtained is given.

Sturgeon (Acipenser rubicundus Le Sueur)

The sturgeon is the largest food fish caught in Lake Nipigon. It is confined largely to shallow water near shore.

Unfortunately, the fish obtained were caught in the pound nets, and, as a result, the digestive tracts were often empty. Enough specimens were obtained, however, to show conclusively that the sturgeon subsists to a very large extent upon *Mollusca*. Nearly all the smaller *Gastropoda* and *Pelecypoda* fall prey to it. A total of 16 species of *Mollusca*, as listed below, were taken from sturgeon stomachs.

Lymnaea galbana
" *emarginata*
" *stagnalis appressa*
" *vahlii*

Valvata sincera
" *tricarinata*
Amnicola limosa
" *sp.*

Planorbis antrosus
" *exacuous*
" *hirsutus*
Physa ancillaria
" *gyrina*
Sphaeriidae 3 sp.

The extent of the list given above proves that *Mollusca* are very important as food for the sturgeon, and indeed may constitute almost 100% of the material present. But often other animals which live on the bottom are eaten, and hence the proportion of *Mollusca* varies greatly.

Common Whitefish (Coregonus clupeaformis Mitchill)

The common whitefish is the most abundant and important food fish taken in Lake Nipigon. It lives mostly in deep water, but occasionally it comes into shallower areas. At such times it feeds extensively on *Mollusca*, but only upon the smaller species, as can be seen from the list following. Out of a total of 155 whitefish examined, the stomachs of all but one contained *Mollusca* and in amounts estimated to range all the way to 100%. The importance of *Mollusca* can be better appreciated if exceptional cases are considered. Two specimens are very impressive examples. In one of these over 4000 *Mollusca* were counted, and in the other over 1800, besides fragments of hundreds more. The species of *Mollusca* found in whitefish stomachs are as follows:

Lymnaea vahlii
" *apicina*
" *galbana*
Planorbis antrosus
" *parvus*
Physa gyrina
" *sp.*
Valvata sincera
" *tricarinata*
Amnicola limosa
" " *porata*
" *sp.*
Sphaeriidae 4 sp.

Round Whitefish (Coregonus quadrilateralis Richardson)

This species was fairly abundant in the lake, although it was not of commercial importance, since it was not large enough to be caught in the 4½ inch gill-net. A total of 41 stomachs were examined, and in 37 of these it was estimated that less than 1% of the food material consisted of *Mollusca*. In the remaining four, the amount was considerably greater, being estimated at 5%, 10%, 20%, and 75% of the total. From this it appears that while *Mollusca* are eaten by the round whitefish to some extent, they are not, as a general rule, a very important constituent.

The following species were identified:

Lymnaea vahlii
" *galbana*
Physa gyrina
Amnicola sp.
Valvata sincera
" *tricarinata*
Sphaeriidae 1 *sp.*

Common Sucker (Catostomus commersoni (Lacépède))

While having no commercial value, the sucker is very abundant in Lake Nipigon. It apparently consumes a large number of *Mollusca*, for 24 out of 25 stomachs which were examined contained them. In 19 of these the amount was estimated to range from 1% to 25%: in the remainder, less than 1%. The species represented are:

Physa gyrina
Planorbis hirsutus
" *parvus*
Valvata sincera
" *tricarinata*
Sphaeriidae 1 *sp.*

Northern Sucker (Catostomus catostomus (Forster))

Twenty-two stomachs of this species were examined and from these it is apparent that the northern sucker takes *Mollusca* in quantity only on rare occasions. Of the material examined 10 stomachs contained no *Mollusca*, 11 less than 1%, and one 20%. The species identified are as follows:

Lymnaea sp.? fragmentary
Planorbis antrosus
" *parvus*
Valvata sincera
Sphaeriidae 2 sp.

Ciscoes

Among the ciscoes of Lake Nipigon there are probably three species, two of which reach such a size as to make them commercially important. They are caught in considerable numbers and are a valuable food fish. They generally inhabit very deep water, and are plankton feeders. In the stomachs examined, 3 out of 47 contained *Mollusca*, and these were small *Sphaeriidae*. Their presence was probably due to the fact that the ciscoes feed at times on the bottom and hence take in *Sphaeriidae* with other small organisms.

The other large fish in the lake are mostly piscivorous and do not, except accidentally or on very rare occasions, take *Mollusca* as food. Included in this group are the pike perch, pike, ling, lake trout, and brook trout. The smaller species, such as the darters and sticklebacks, live on small organisms such as insects and larvae of various kinds, and do not make much use of *Mollusca*.

COMPARISON OF LAKE NIPIGON WITH OTHER LAKES

Work similar to that done in Lake Nipigon has not, as yet, been carried out very extensively in North America, except in Lake Mendota in Wisconsin and Lake Oneida in New York. It is desirable, therefore, that some comparison should be made between these lakes and Lake Nipigon.

As regards physical features Lake Nipigon appears to have very little in common with the other two, which are both small shallow lakes, whereas Lake Nipigon is both very

large and very deep. The greatest depth from which dredgings were taken in Lake Nipigon was 192 ft., but depths of over 300 ft. were sounded, and McInnes (1894) records a depth of 402 ft. In Lakes Mendota and Oneida work does not appear to have been carried on much below 30 ft. Moreover, Lake Nipigon is largely open water, and the only situations which correspond, in general, with conditions in the other two lakes are the small sheltered bays. Even in these, Lake Nipigon has not the large masses of higher vegetation and abundance of algae which is apparently a characteristic feature of the other lakes. The contrast between the Canadian and United States lakes is that between a young primitive lake, and old highly evolved lakes, as defined by Pearsall (1921).

Corresponding with the difference in physical features, there is also a difference in the distribution of animals, and particularly *Mollusca*, in the lakes considered. The number of species of *Mollusca* found in Lake Oneida was 91 (Baker, 1918), whereas in Nipigon the total was 44. Figures from Lake Mendota are apparently not available. In regard to distribution of species, it appears, that in Lake Nipigon most forms are found in greatest abundance in shallower water than in the other lakes. This may be due to the fact that Lake Nipigon is subject to storms of considerable violence, with the result that the *Mollusca* seek the shallower water of protected bays. The storms, moreover, result in a washing of the exposed shores and a gradual transfer of food material and débris to quiet bays. Furthermore, the total average number of *Mollusca* per unit area in Lake Nipigon is intermediate between that of the other two—the results from dredging operations showing an average of 165 *Mollusca* per square metre in the Canadian lake.

While the results of stomach analysis show that *Mollusca* are a very valuable component of fish food, it is also evident that the number of species which feed on them is less in Lake Nipigon than in Lake Oneida, where some 18 out of 41 species consume them (Baker, 1916). This is, of course, due to the limited number of species in Lake Nipigon.

CONCLUSION

The results considered as a whole bring out several important facts: 1. As regards animal life, and particularly *Mollusca*, the most productive parts of the lake are small sheltered bays and the channels between islands. This is true especially where the bottom is covered with sand or mud, on which there is much organic débris to furnish food material. A depth of less than 30 ft. is the optimum, in general, for bottom organisms. Clean sand or clay bottoms, exposed points, and very deep water are relatively unproductive.

2. The fact that there is an average of 165 *Mollusca* per sq. metre of bottom shows that there must be an enormous number available in the lake. Nearly all species represented are valuable as food for whitefish and sturgeon, and these are the two most valuable fish in the lake.

3. The large molluscan resources suggest that sturgeon could be supported in much larger numbers than occur at the present time. As a result, some attempt should be made to propagate this fish artificially, as is done in the case of the whitefish.

While the work done makes no pretence of being exhaustive, nevertheless, the results afford some idea of the productivity of the lake in regard to *Mollusca*. The dredging operations give an accurate and efficient quantitative method of studying the animal population of the lake bottom. The importance of this work can be realized when it is considered that the bottom organisms furnish a large part of the fish food of the lake. Hence, in the intensive cultivation of any body of water, including re-stocking and the introduction of new species of fish, a knowledge of the food resources is absolutely essential. In this report an attempt has been made to furnish this information with respect to the *Mollusca* of Lake Nipigon.

LITERATURE CITED

Baker, Frank C., 1916. The Relation of Mollusks to Fish in Oneida Lake. Tech. Pub. No. 4, N.Y. State College of Forestry, Syracuse University, vol. XVI, No. 21, pp. 23-324.

Baker, Frank C., 1918. The Productivity of Invertebrate Fish Food on the Bottom of Oneida Lake, with Special Reference to Mollusks. Tech. Pub. No. 9, N.Y. State College of Forestry, Syracuse University, vol. XVIII, No. 2, pp. 1-264.

McInnes, William, 1894. Summary Report on the Survey of Lake Nipigon. Geological Survey, Canada, New Series, vol. VII, part A, pp. 48-51.

Muttkowski, R. A., 1918. The Fauna of Lake Mendota. Trans. Wis. Acad. Science, Arts and Let., vol. XIX, part I, pp. 374-384.

Pearsall, W. H., 1921. The Development of Vegetation in the English Lakes, considered in relation to the general Evolution of Glacial Lakes and Rock Basins. Proc. Royal Society, B, vol. 92, pp. 259-284.

UNIVERSITY OF TORONTO STUDIES

PUBLICATIONS OF THE
ONTARIO FISHERIES RESEARCH LABORATORY
No. 15

THE BOTTOM ORGANISMS OF LAKE NIPIGON

BY

F. B. ADAMSTONE and W. J. K. HARKNESS
OF THE DEPARTMENT OF BIOLOGY
UNIVERSITY OF TORONTO

TORONTO
THE UNIVERSITY LIBRARY
1923

THE BOTTOM ORGANISMS OF LAKE NIPIGON

As one phase of the investigation of the available food supply for the fish population of Lake Nipigon, an extensive series of dredging operations was carried out in order to obtain quantitative data in regard to those organisms which live on the bottom of the lake and form the food of those species of fish which feed at the bottom, such as the sturgeon, the whitefishes and the suckers. Special attention was paid to the Mollusca which were found to be one of the most important constituents of the bottom fauna and this part of the work is dealt with by Mr. Adamstone in a separate paper which includes a general account of the apparatus and methods employed in the dredging operations.

The present paper presents the results obtained *in toto* and such particular data for the various groups, other than the *Mollusca*, as it has been possible to bring to completion at the present time.

The following groups of animals were secured in the bottom samples: *Nematoda*, *Acanthocephala*, *Oligochaeta*, *Hirudinea*, *Crustacea*, *Insecta*, *Arachnida* and *Mollusca*. The details concerning the number of specimens of each group obtained in each dredging, as well as information regarding depth and character of bottom, are given in the appended series of tables.

I. Nematoda

The free-living round worms were not very abundant, for a total of only 77 specimens was obtained in all the dredgings. These were about equally distributed on mud and sand bottoms, but were somewhat more numerous in shallower water. The specimens were submitted to Dr.

N. S. Cobb of the U.S. Department of Agriculture, who kindly undertook to identify them. He has reported the following species:

1. *Dorylaimus crassus* de Man.
2. " *speciosus* (n. sp. Cobb mss.)
3. " *canadensis* (n. sp. Cobb mss.)
4. *Mermithidae* several sp.

Two of the species listed, viz., *Dorylaimus speciosus* and *Dorylaimus canadensis*, are new species. There are also several species of *Mermithidae* which have not yet been determined.

II. ACANTHOCEPHALA

This class is represented by five specimens which were dredged up from a depth of 36 ft., off a clay bottom (Series XIV, D. 8). Their occurrence in this particular place is thought to have been accidental, most probably, since all members of the group are parasitic.

III. OLIGOCHAETA

Oligochaetes were obtained very frequently and in the most diverse situations. Identification of the species has not yet been completed so that it is impossible at present to give any details in this regard. An attempt has been made, however, to work out the distribution of the class as a whole and in the following table the average number of specimens per

Depth	No. on Mud	No. on Sand	Total	Av.
0- 3	59	26	85	3.7
3- 6	69	61	130	4.8
9	101	54	155	7.4
12	19	69	88	4.4
15	19	32	51	2.5
18	25	28	53	2.9
21	21	16	37	1.8
24	12	7	19	2.3
27	6+(1 clay)	3	10	1.2
30	9	6	15	1.9

unit area (81 sq. inches) is given for intervals of 3 feet in depth down to 30 feet. Beyond this, specimens were not numerous although some were obtained from various depths down to 178 feet.

From the table it can be seen that the number of individuals was almost the same on mud and sand bottoms. Distribution according to depth is illustrated by the curve, Fig. 1, from which it is evident that the optimum depth for these animals is between 6-9 ft. The fall in the curve shows that they are most abundant in shallow water especially between depths of 3 and 12 feet.

IV. HIRUDINEA

Leeches were uncommon in the material secured in dredging. This, however, was to be expected, since they usually seek more protected situations among stones, and in such places the dredge could not be used. Some shore collections were made but these were not very extensive. Specimens were submitted to Prof. J. P. Moore of the University of Pennsylvania, who very kindly identified them. The species reported are:

1. *Actinobdella triannulata* (n. sp. Moore mss.)
2. *Dina parva* Moore.
3. *Erpobdella punctata* (Leidy)
4. *Glossiphonia complanata* (Linn)
5. *Haemopsis marmoratis* (Say)
6. *Helobdella stagnalis* (Linn)
7. *Nephelopsis obscura* (Verrill)
8. *Piscicola milneri* (Verrill)

Of the eight species listed the first, namely, *Actinobdella triannulata*, is noted tentatively as a new species.

V. CRUSTACEA

Representatives of three sub-classes of *Crustacea* occurred amongst the bottom organisms, including the following:

1. *Branchiopoda*—Order *Cladocera*
2. *Ostracoda*
3. *Malacostraca*—Order *Amphipoda*

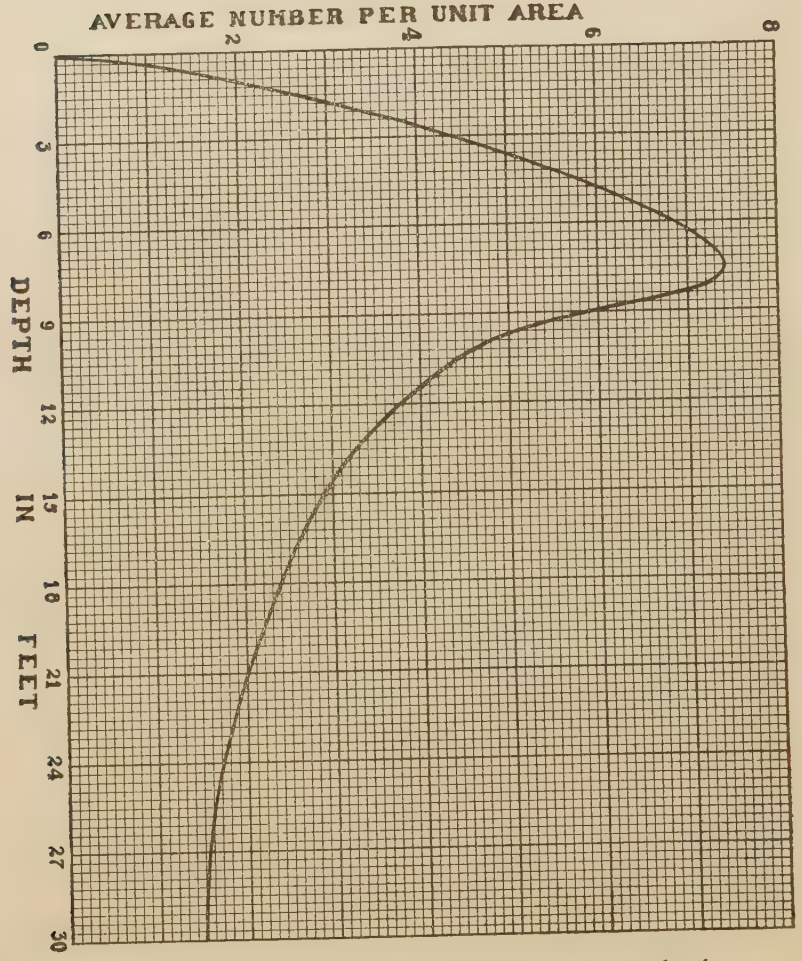


FIG. 1. Curve illustrating distribution according to depth. Oligochaeta.

Cladocera: Very few specimens of *Cladocera* were obtained. This was due, most probably, to the fact that they were usually lost, on account of their small size, in the process of washing and cleaning the material. This was unfortunate especially since some of these forms are important constituents in the food of bottom feeding fish.

Four species were identified, namely:

1. *Alona affinis* (Leydig)
2. *Chydorus sphaericus* var *coelatus* Schoedler
3. *Sida crystallina* (Müller)
4. *Eurycercus lamellatus* (Müller)

2. *Ostracoda:* The *Ostracoda*, like the *Cladocera*, were very frequently lost in washing the samples. However, in some 23 dredgings a number of specimens were found. The different species amongst them have not yet been determined. Examination of fish stomachs showed that in some localities *Ostracoda* must be extremely abundant and may form a very high percentage of the stomach contents.

3. *Amphipoda:* *Amphipoda* were quite common throughout the southern end of the lake. Three species were obtained:

1. *Pontoporeia hoyi* Smith
2. *Hyalella knickerbockeri* (Bate)
3. *Gammarus limnaeus* Smith

Pontoporeia hoyi Smith

Of the three species, *Pontoporeia hoyi* was by far the most numerous. It was taken in almost all situations and at all depths down to 192 feet. Data pertaining to the distribution of this species are given in the following table and from it the curve, Fig. 2A, has been drawn.

The curve in Fig. 2A shows that this species is not very plentiful in shallow water but it becomes more abundant as the depth increases. This, of course, does not go on indefinitely but after a depth of about 75 ft. is reached, the

distribution becomes more uniform and the maximum is apparently reached between 120-150 ft.

Depth	Total	Av.
0-30	512	3.05
30-60	428	12.23
60-90	305	21.78
90-120	87	21.75
120-150	231	33.0
150-180	85	17.0
180-192	45	.....

Hyalella knickerbockeri (Bate)

In contrast with the preceding species this amphipod was comparatively scarce. Usually it is found, with *Pontoporeia hoyi*, in about equal numbers, but the dredgings in Lake Nipigon yielded a much smaller number of specimens. It was obtained mostly in shallow water but a few specimens were brought up from deeper places. Data with regard to the abundance of this species at various depths are given in the following table.

Depth	Total	Av.
0-3	5	.31
3-6	39	1.5
9	13	.62
12	23	1.15
15	29	1.45
18	30	1.66
21	79	3.95
24	1	.12
27	5	.62
48	3	
90	2	
159	2	

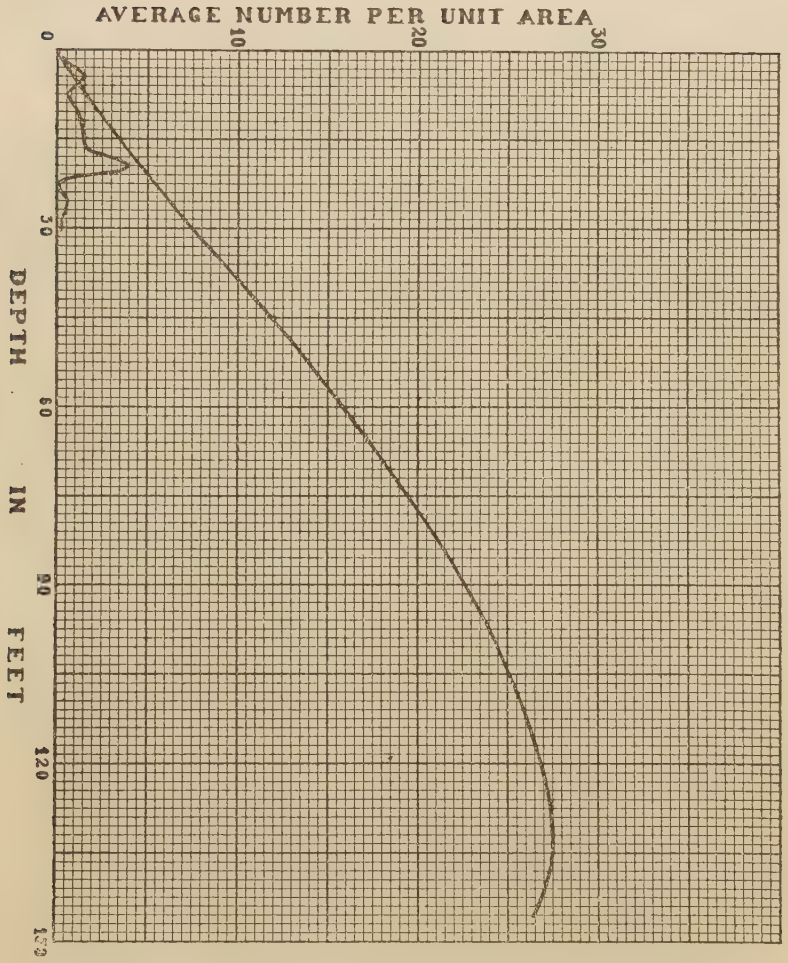


FIG. 2. Curves illustrating distribution according to depth.
Amphipoda. A. Pontoporeia hoyi (Upper).
B. Hyalella knickerbockeri (Lower).

The curve, Fig. 2B, drawn from the results given above, shows that there is a decided difference in the distribution of this species as compared with the other, not only in regard to relative abundance, but also in the fact that it is practically confined to shallow water near shore.

Gammarus limnaeus Smith

This species was quite rare and was obtained on only a few occasions and then only in the protected channels between islands. A total of 7 specimens was secured and these came from some of the outer Shakespeare islands in water from 3 to 21 feet deep. The species is apparently of very little importance numerically.

VI. Insecta

The larval and nymphal stages of several insects occurred in the material from dredgings, and representatives of the following Orders were found amongst them: *Ephemerida*, *Odonata*, *Neuroptera*, *Trichoptera*, *Coleoptera*, *Diptera* (chiefly *Chironomidae*).

Ephemerida

May fly nymphs were found most frequently in bottom samples taken from small sheltered bays. The specimens obtained were identified by Dr. W. A. Clemens who reports the species enumerated below:

1. *Hexagenia bilineata* Say
2. *Ephemera simulans* Walker
3. *Caenis diminuta* Walker
4. *Ephemerella* sp.
5. *Baetis* sp.

The first three species were fairly common but the remaining two were dredged up on only a few rare occasions. A summary of the numbers obtained at different depths is given in the following table from which the graphs, Fig. 3, have been drawn.

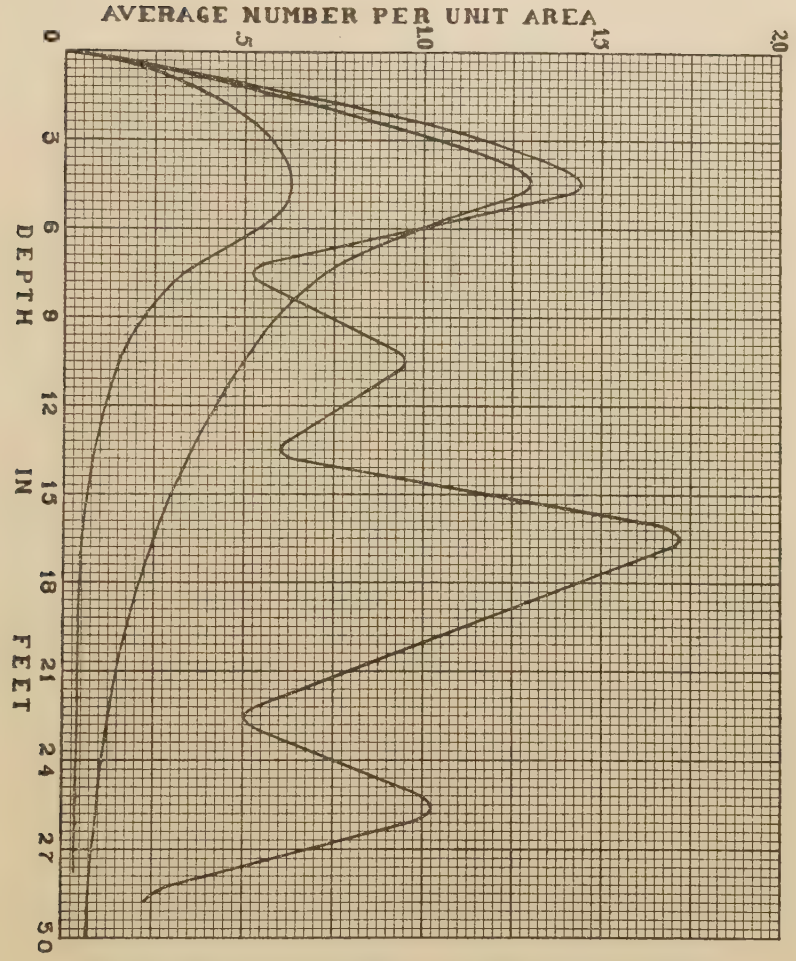


FIG. 3. Curves illustrating distribution according to depth. Ephemerida. A. Hexagenia bilineata (Upper).
B. Ephemera simulans (Middle).
C. Caenis diminuta (Lower).

Depth (ft.)	No. of Dredgings	*Hexagenia bilineata*			*Ephemera simulans*			*Caenis diminuta*			*Ephemerella* sp.	*Baetis* sp.
		Sand	Mud	Average	Sand	Mud	Average	Sand	Mud	Average		
0-3	18	7	4	.65	6	4	.60	1	6	.41	..	..
3-6	27	4	35	1.44	32	3	1.55	12	5	.37	4	1
6-9	21	1	10	.52	8	4	.62	2	5	.33	..	..
9-12	20	1	18	.95	2	5	.35	..	3	.10	..	..
12-15	20	1	11	.60	7	1	.40	2	..	.10	..	..
15-18	18	5	26	1.72	6	2	.44	..	..	0	..	..
18-21	20	1	19	1.11	2	..	.11	..	1	.06	..	..
21-24	8	0	4	.5	0	1	.12	..	..	..	..	..
24-27	8	2	2	1.12	1	..	.12	1	..	.12	..	..
27-30	8	..	2	.25	..	..	..	..	..	..	..	..
30-33	6	..	..	..	1	..	.16	..	..	..	..	..
33-36	..	..	..	..	..	..	..	..	..	..	..	..
36-39	..	..	..	..	..	..	..	..	..	..	..	..
48	..	..	..	..	..	..	..	..	2	..	..	..

From the table it is evident that the species *Hexagenia bilineata* prefers a muddy bottom, whereas the species *Ephemera simulans* is most abundant in sandy situations. The latter as well as *Caenis diminuta* are most numerous in shallow water, as can be seen from the curves, Fig. 3, and their optimum range is between depths of 0-9 feet. The other species, *Hexagenia bilineata*, is apparently fairly uniformly distributed over all depths between 5-25 ft., this being probably the significance of the very irregular curve representing the species.

Trichoptera

A total of 116 caddis fly larvae were obtained in the dredgings, amongst these were representatives of nine families:

Rhyacophilidae
Hydropsychidae
Psychomyidae
Polycentropidae
Sariscostomatidae
Mollanidae
Leptoceridae
Phryganidae
Limnophilidae

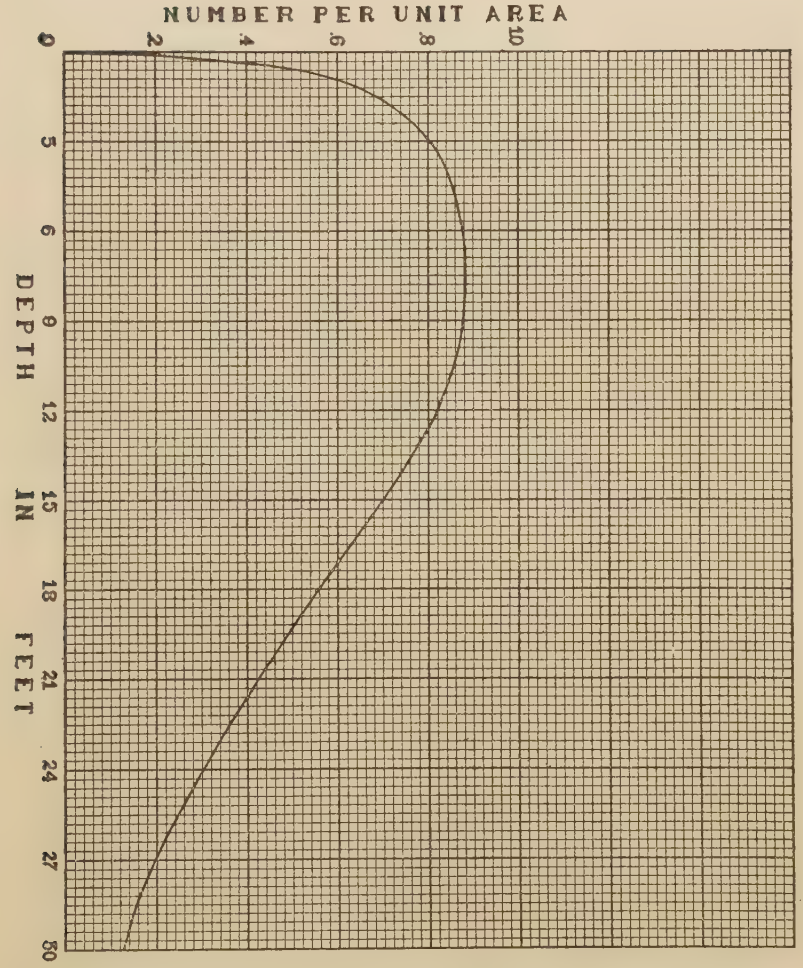


FIG. 4. Curve illustrating distribution according to depth. Trichoptera.

The specific determinations have not yet been completed and hence no data will be given at present concerning them. The average numbers taken at various depths are given in the table below and from it the graph, Fig. 4, illustrating the distribution of the order with depth has been drawn.

Depth	No.	Av.	Depth	No.	Av.
0-3	12	.66	24	1	.12
3-6	22	.81	27	4	.50
9	18	.86	30	3	.37
12	18	.90	39	1	..
15	15	.75	45	2	..
18	14	.78	48	1	..
21	5	.25	..	..	..

From the curve it is evident that caddis larvae are most numerous in shallow water between 0-18 feet deep. They were found mostly in small protected bays or in the channels between islands.

Diptera—Chironomidae

Of all the bottom organisms, the larvae of the *Chironomidae* proved to be the most abundant. Owing to the large amount of material obtained it has been impossible to bring to completion at the present time the details in respect of specific distribution, relative abundance and importance. The results here presented deal for the most part with the group as a whole. Table I gives the data concerning the numbers obtained at the various depths and on the various kinds of bottom. Graph 5 shows the quantitative distribution on the basis of the average number of larvae per 15-foot intervals.

The results show that in a total of 228 dredgings extending to a depth of 180 feet, 3723 larvae were obtained, this being an average of 16 per dredging, that is, per 81 square inches. In some cases as high as 159 larvae were obtained from the above unit area.

About two-thirds of the dredgings, that is 168, were taken in water less than 30 feet in depth and in this range the largest number of *Chironomidae* were found to occur, namely 3225, which is an average of 19 per 81 square inches. Between the depths of 30 and 60 feet the number of larvae tended to decrease but there was a marked increase again between 60 and 75 feet. In water beyond 75 feet in depth the number of larvae was relatively small, but even at a depth of 178 feet eight were obtained in a single dredging.

Table II is given to illustrate the distribution of species as obtained in four series of dredgings. No specific names are used because some of the identifications are tentative and because it is thought that several species are new to science. Life history studies will be necessary in many cases before identifications can be completed. It is probable that certain species are characteristic of certain limited ranges of depth, while others are widely distributed. Species 1, for example, evidently occurs only in shallow water and is abundant there; species 22, on the other hand, is doubtless a deep water form, while species 6 was found at depths from 12 to 150 feet.

TABLE I

Depth	No. of dredgings	Total No. of larvae	Average per dredging	Average per dredging per 15 ft.		
				Mud	Sand	Clay
0-15	106	2153	20.3	26.1	16.3	0.0
15-30	62	1072	17.3	26.5	9.6	15.0
30-45	22	236	10.8	12.1	11.0	1.5
45-60	13	78	6.0	8.0	3.0	0.0
60-75	8	115	14.7	20.1	1.0	5.0
75-90	6	13	2.2	1.5	..	2.5
90-105	2	5	2.5	5.0	...	0.0
105-120	2	6	3.0	6.0	..	0.0
120-135	1		5.0	5.0	..	0.0
135-150	6	38	4.6	4.6	..	4.6
150-165	4	6	1.5	1.0	..	2.0
165-180	1	8	8.0	8.0	..	0.0

CHIRONOMIDAE: TABLE II

	Depth	Sp. 1	Sp. 2	Sp. 3	Sp. 4	Sp. 5	Sp. 6	Sp. 7	Sp. 8	Sp. 9	Sp. 10	Sp. 11	Sp. 12	Sp. 13	Sp. 14	Sp. 15	Sp. 16	Sp. 17	Sp. 18	Sp. 19	Sp. 20	Sp. 21	Sp. 22	Sp. 23	Sp. 24	Sp. 25	Sp. 26
Series II																											
1	7 ft.	..	4	..	..	1	..	1	..	..	..	1	..	..	..	..	..	..	2	..	..	..	..	1	..	..	1
2	45	..	..	1	..	..	..	1	..	..	..	1	..	..	..	..	..	2	..	..	..	..	..	..	..	..	..
3	120	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
4	162	1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
5	93	..	..	..	..	..	1	1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
6	72	..	..	..	..	..	..	1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
7	60	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
8	12	11	..	..	..	1	..	2	..	..	..	2	..	..	1	..	..	..	..	3	..	..	..	..	..	1	..
9	11	2	3	..	..	4	..	5	..	1	..	3	..	..	6	..	..	..	11	2	1	..	..	..	..	..	..
Series III																											
1	6	18	..	3	1	1	..	1	..	1	..	3	..	..	..	..	..	..	..	2	..	..	..	..	..	..	..
2	12	6	..	1	..	2	1	1	1	1	..	1	..	2	1	1	1	..	..	..	..	..	..	..	..	..	..
3	21	3	..	..	..	..	..	1	..	..	1	1	2	..	..	..	1	..	..	..	3	..	..	..	..	..	..
4	45	1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Series IV																											
1	12	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
2	21	..	..	..	..	1	..	..	..	..	..	..	..	..	..	..	1	..	..	..	..	..	..	..	..	..	..
3	27	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
4	30	..	..	..	..	..	..	1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
5	48	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
6	159	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1	..	..	..	..	..

CHIRONOMIDAE: TABLE II—*Cont.*

	Depth	Sp. 1	Sp. 2	Sp. 3	Sp. 4	Sp. 5	Sp. 6	Sp. 7	Sp. 8	Sp. 9	Sp. 10	Sp. 11	Sp. 12	Sp. 13	Sp. 14	Sp. 15	Sp. 16	Sp. 17	Sp. 18	Sp. 19	Sp. 20	Sp. 21	Sp. 22	Sp. 23	Sp. 24	Sp. 25	Sp. 26
Series V																											
1	150	..	..	..	..	..	1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	3	..	..	..	..
2	150	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
3	156	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1	..	..	..	..
4	163	..	..	..	..	..	..	..	1	..	..	..	..	..	..	..	..	..	..	..	..	..	2	..	..	..	..
5	80	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
6	96	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
7	78	..	..	..	..	..	..	..	..	..	..	1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
8	45	..	..	..	..	..	5	..	..	..	..	1	..	..	..	..	..	2	..	..	..	..	8	1	1	..	..
9	84	..	..	..	..	..	..	..	..	..	..	4	..	..	..	..	..	..	..	..	..	..	2	..	..	..	..
10	192	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..

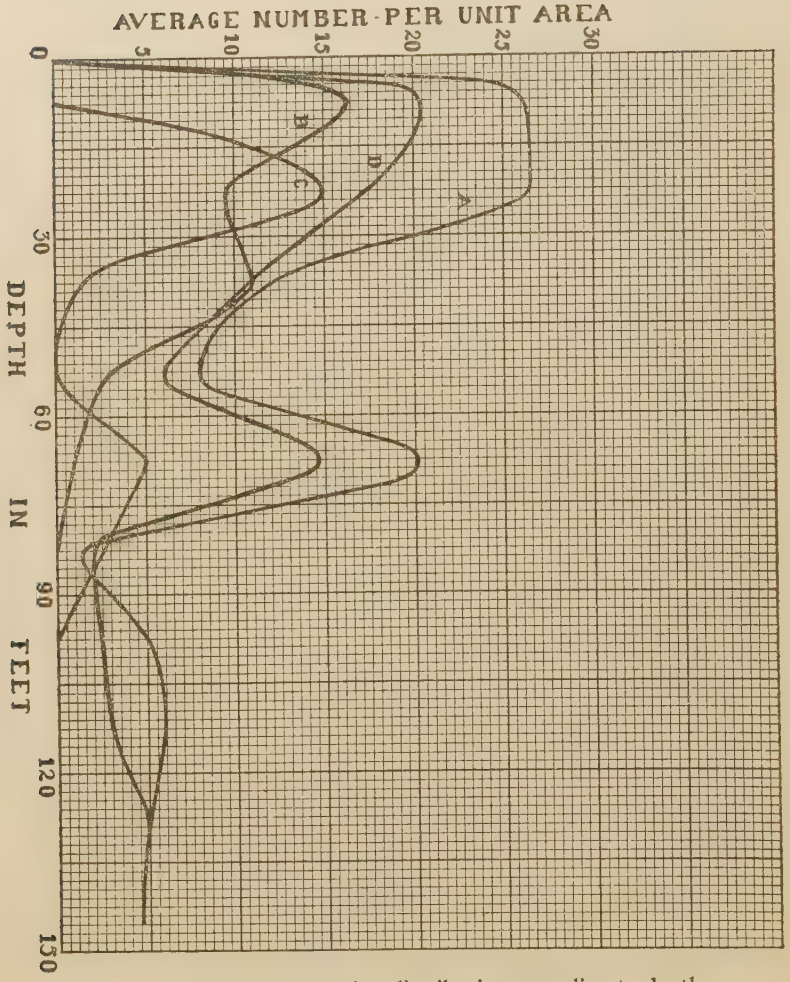


FIG. 5. Curve illustrating distribution according to depth. Chironomidæ. A. On mud bottom.
B. On sand bottom.
C. On clay bottom.
D. On all bottoms.

The curves would seem to graphically illustrate this point also, in that, on the various kinds of bottom there are depths at which larvae were especially abundant, doubtless representing associations of species.

The number of larvae on the bottom of the lake of course is not constant over any extended period of time during the open season. Throughout the summer and autumn large numbers of larvae are maturing, pupating and adults emerging. Eggs are being deposited and larvae hatching. No doubt considerable numbers of small, newly hatched individuals were lost in the processes of sifting materials and the actual numbers on the bottom were slightly larger than the results obtained would indicate. It is evident, however, in spite of the fluctuations in numbers, that the supply of larvae available as food for fish is always large. This would be expected of course in view of the large numbers of species with their extended periods of emergence, and is confirmed by the dredging results. Adults were observed in large numbers during the three months spent on the lake.

As a preliminary experiment for obtaining some information regarding the extent of this life history cycle, a tent trap covering 540 sq. inches of water surface was constructed and set out at various times. The results obtained were as follows:

STATION 1. Depth of water 5 ft., 10 yds. from shore.
July 15, 96 hrs., windy and rain, 17 adults and 9 pupae.
Aug. 1, 9 hrs., day, windy, clear, 1 adult.
Aug. 2, 13 hrs., night, calm, clear, 8 adults.
Aug. 16, One dredging, bottom sandy, 19 larvae = 127 per 540 square inches.

STATION 2. Depth of water 8 ft., 50 yards from shore.
Aug. 4, 12 hrs., night, clear and warm, 1 adult.
Aug. 5, 12 hrs., day, wind and rain, 0 adults.
Aug. 16, One dredging, bottom—debris, sand, stones; 39 larvae = 260 per 540 square inches.

Station 3. Depth of water 10 ft., 80 yards from shore.
Aug. 9, 12 hrs., night, windy and rainy, 50 adults.
Aug. 16, 12 hrs., day, calm, clear and cool, 90 adults.
Aug. 19, 9 hrs., day, windy and cloudy, 5 adults.
Aug. 16, One dredging, bottom—debris, sand and stones; 54 larvae = 360 per 540 square inches.

The results obtained at Station 3 are perhaps the most satisfactory and give some idea of the extensive emergings which may take place.

In Lake Nipigon the *Chironomidae* are very important economically in that the larvae form one of the most important sources of fish food. The following fish have been found to feed more or less extensively on the larvae and to some extent on the pupae and adults: sturgeon, northern sucker, common sucker, two minnows (*Notropis hudsonius* and *Couesius plumbeus*), common whitefish, round whitefish, ciscoes, trout perch, young small mouth black bass, young yellow perch and ling. One whitefish, 28 cm. in length, taken June 30, contained 354 larvae, constituting approximately 70% of the stomach contents. A sturgeon, taken June 24, had eaten at least 331 larvae. Percentages in bottom-feeding fish ranged as high as 96%. The *Chironomidae* thus play a very significant rôle in the economy of the lake.

Besides the orders of Insecta which have been considered in more detail, specimens of a few others were obtained. These include:

Neuroptera—*Sialidae*
Coleoptera—{*Dytiscidae*, *Chrysomelidae*}
Odonata

The occurrence of these organisms seems to have been more or less incidental in dredging operations although they were certainly abundant and widely distributed. However, the number secured in bottom samples in this season was so small that no statement can be made in regard to them.

VII. ARACHNIDA

In a number of situations specimens of water mites (*Hydracarina*) were dredged up. The total, however, was small and since identifications have not yet been completed details will be given in a future report.

VIII. MOLLUSCA

Details concerning the species, abundance and distribution of this group are given in another paper.

CONCLUSIONS

I. Study of the bottom fauna of Lake Nipigon has revealed an abundant and varied population of many different kinds of organisms, and it has been found, with few exceptions, that the shallow waters of small protected bays or the channels between islands were most productive of these animals. The open lake was relatively unproductive. These facts are apparently quite in accord with observations made in other bodies of water which have been studied in a similar manner.

II. Although the data at hand, as a result of the first season's study, are perhaps not quite extensive enough to allow of making general statements in regard to the abundance of some of the animals found on the lake bottom, it is desirable, nevertheless, that some estimate of the number of organisms available on a unit area of the bottom should be made. In the following table the average number of animals of each of the various groups is given for a unit area.

	Av. per sq. yd.	Av. per sq. metre
Mollusca	138	165
Oligochaeta	51	63
Amphipoda	131	160
Ephemerida	20	25
Trichoptera	8	10
Chironomidae	253	303
Animals of all kinds	630	753

III. The results given in the table indicate a rich source of food supply for fish and the fact that it is drawn upon very extensively by several species has been amply demonstrated by the examination of stomach contents.* The common whitefish (*Coregonus clupeaformis*), which is the most abundant and most important commercial fish in the lake, feeds almost exclusively upon bottom organisms. The sturgeon (*Acipenser rubicundus*), also important commercially, is likewise a bottom feeder. Three other species, although not marketed at the present time, depend almost entirely upon this source. These are the round whitefish (*Coregonus quadrilateralis*), the common sucker (*Catostomus commersonii*), and the northern sucker (*Catostomus catostomus*).

The importance of the evaluation of the bottom fauna in any body of water in any undertaking relating to fish production becomes quite evident when its importance as fish food is taken into consideration.

*The results of the examination of stomach contents of various species of fish are given in another paper in the series.

ORIENT BAY AT MACDIARMID — Series II

Dredging	1	2	3	4	5	6	7	8	9	Totals
Depth (in feet)	7	45	120	162	93	72	60	12	11	..
Character of Bottom	Coarse Grit	Grit on Clay	Clay	Mud	Mud	Sand	Rock	Sand	Sand	..
Distance from Shore (yds.)	10	30	75	175	600	1200	1400	1800	1900	..
Mollusca	16	..	..	..	..	..	..	11	21	48
Chironomidae	12	5	..	1	2	1	..	26	32	79
Ephemeridae	1	..	..	..	..	..	..	..	..	1
Amphipoda	..	3	5	36	25	4	..	..	..	73
Oligochaeta	3	..	..	1	1	..	..	7	47	59
Nematoda	..	..	..	..	..	..	..	1	..	1
Totals	32	8	5	38	28	5	..	45	100	261

SAND POINT BAY	Series III				SANDY RIVER TO N. SHAKESPEARE			Series IV			
											Totals
Dredging	1	2	3	4	1	2	3	4	5	6	..
Depth (in feet)	6	12	21	45	12	21	27	30	48	159	..
Character of Bottom	Gravel	Gravel	Sand	Mud	Clay	Sand	Sand	Sand	Sand	Mud	..
Distance from Shore (yds.)	30	60	120	440	150	250	850	1200	2800	4550	..
Mollusca	6	5	4	..	..	4	..	16	10	..	45
Chironomidae	33	37	14	1	..	2	1	3	..	1	92
Trichoptera	3	1	1	..	..	1	..	..	..	..	6
Ephemeridae	4	..	1	..	..	..	..	..	..	..	5
Amphipoda	13	3	4	4	..	13	..	..	..	6	43
Nematoda	1	..	..	..	..	..	..	..	..	1	2
Oligochaeta	2	3	7	..	..	..	..	1	..	..	13
Hydracarina	1	..	1	..	..	1	..	..	..	..	3
Totals	63	49	32	5	..	21	1	20	10	8	209

SHAKESPEARE ISLAND TO SANDY RIVER — Series V

Dredging	1	2	3	4	5	6	7	8	9	10	Totals
Depth (in feet)	150	150	156	163	80	96	78	45	84	192	..
Character of Bottom	Clay	Clay	Clay	Clay	Clay	Clay	Clay	Gravel	Clay	Mud	..
Distance from Shore	50 yd	100 yd	200 yd	400 yd	800 yd	1 mile	2 miles	3 miles	$3\frac{1}{4}$ miles	6 miles	..
Mollusca	..	..	..	..	..	..	..	8	..	1	9
Chironomidae	3	..	1	3	..	..	1	23	..	..	31
Amphipoda	36	10	25	8	3	13	21	6	28	45	195
Ostracoda	..	..	..	1	..	..	..	..	..	..	1
Oligochaeta	..	..	1	..	..	..	..	..	1	..	2
Nematoda	..	..	..	1	..	..	..	..	..	..	1
Trichoptera	..	..	..	..	..	..	..	2	..	..	2
Totals	39	10	27	13	3	13	22	39	29	46	241

SAND POINT BAY (Off McColeman's Dock) Series VI

										Totals
Dredging	1	2	3	4	5	6	7	8	9	..
Depth (in feet)	6	9	12	14	15	15	15	15	16	..
Character of Bottom	Sand	Sand	Sand	Sand	Sand & Gravel	Sand	Sand & Gravel	Sand & Gravel	Sand & Gravel	..
Distance from Shore (ft.)	75	100	150	175	200	225	250	275	300	..
Mollusca	..	..	3	1	3	1	..	6	15	29
Chironomidae	6	6	8	12	1	..	4	5	18	60
Amphipoda	..	..	..	4	..	..	..	..	12	16
Oligochaeta	..	..	1	4	..	..	..	..	3	8
Ephemeridae	..	..	..	..	..	..	1	1	..	2
Hydracarina	..	..	..	..	..	..	..	..	..	..
Totals	6	6	12	21	4	1	5	12	48	115

SAND POINT BAY (Off McColeman's Dock) Series VI

									Totals
Dredging	10	11	12	13	14	15	16	17	..
Depth (in feet)	15	21	27	39	53	60	69	75	..
Character of Bottom	Gravel	Gravel	Mud	Clay	Clay	Mud	Mud	Clay	..
Distance from Shore (ft.)	330	375	450	600	750	900	1200	1500	..
Mollusca	6	1	3	..	..	..	..	..	10
Chironomidae	4	4	10	..	..	2	7	5	32
Amphipoda	..	..	..	13	11	7	21	25	77
Oligochaeta	1	1	5	..	..	1	..	..	8
Ephemeridae	..	..	1	..	..	..	..	..	1
Hydracarina	..	..	2	..	..	..	..	..	2
Totals	11	6	21	13	11	10	28	30	130

BAY EAST OF COOKE POINT — Series VIII

											Totals
Dredging	1	2	3	4	5	6	7	8	9	10	..
Depth (in feet)	15	15	18	21	21	18	23	30	33	48	..
Character of Bottom	Sand	Sand	Sand	Sand	Gravel	Rock	Sand & Rock	Sand & Rock	Sand & Gravel	Mud	..
Distance from Shore (yds.)	100	150	200	250	325	400	550	880	1100	1800	..
Mollusca	2	3	1	3	1	5	..	3	..	..	18
Chironomidae	7	23	12	40	32	10	..	24	5	14	167
Amphipoda	3	3	..	..	..	..	..	5	1	8	20
Oligochaeta	4	11	1	2	1	1	4	4	2	7	37
Nematoda	..	6	..	1	..	2	..	2	..	5	16
Trichoptera	..	1	1	..	..	..	..	..	..	..	2
Hydracarina	..	..	..	1	1	..	..	..	..	1	3
Ephemeridae	..	..	..	1	..	..	..	..	..	..	1
Totals	16	47	15	48	35	18	4	38	8	35	264

BLACKWATER BAY — Series IX

									Totals
Dredging	1	2	3	4	5	6	7	8	..
Depth (in feet)	8	9	18	21	21	27	30	33	..
Character of Bottom	Sand	Sand	Sand	Sand	Sand	Sand	Sand	Sand	..
Distance from Shore (yds.)	275	300	370	450	525	600	700	880	..
Mollusca	..	..	..	1	..	5	7	2	15
Chironomidae	1	10	..	3	14	4	2	11	45
Amphipoda	..	..	2	2	..	2	10	3	19
Oligochaeta	..	..	..	..	1	..	1	..	2
Nematoda	..	..	..	..	..	..	2	..	2
Ephemeridae	1	..	..	..	..	..	..	..	1
Hydracarina	..	..	..	..	..	1	..	..	1
Totals	2	10	2	6	15	12	22	16	85

BLACKWATER BAY

Series X

									Totals
Dredging	1	2	3	4	5	6	7	8	..
Depth (in feet)	12	21	24	27	29	36	39	39	..
Character of Bottom	Sand	Gravel	Sand	Sand	Sand	Sand	Sand	Sand	..
Distance from Shore (yds.)	50	100	150	200	300	700	900	900	..
Mollusca	..	4	..	1	..	8	..	9	22
Chironomidae	8	19	4	2	1	5	2	5	46
Amphipoda	1	..	1	..	..	..	..	..	2
Oligochaeta	..	2	..	..	..	..	1	..	3
Trichoptera	3	..	..	..	..	..	..	..	3
Totals	12	25	5	3	1	13	3	14	76

SOUTH SHAKESPEARE ISLANDS — Series XI

									Totals
Dredging	1	2	3	4	5	6	7	8	..
Depth (in feet)	3	6	27	48	48	54	51	30	..
Character of Bottom	Rock	Sand	Clay	Ooze	Ooze	Ooze	Ooze	Ooze	..
Distance from Shore (yds.)	5	15	80	200	400	600	800	900	..
Mollusca	4	53	..	..	..	..	..	1	58
Chironomidae	11	13	15	5	..	4	9	..	57
Amphipoda	..	..	20	32	9	63	89	2	215
Oligochaeta	3	2	1	2	1	18	10	1	38
Nematoda	..	1	..	1	..	1	..	..	3
Ephemeridae	1	5	6	3	..	..	..	2	17
Trichoptera	..	3	1	1	..	..	..	1	6
Hydracarina	..	..	..	1	..	..	..	..	1
Totals	19	77	43	45	10	86	108	7	395

EAST SHAKESPEARE ISLANDS — Series XII

Dredging	1	2	3	4	5	6	7	Total ..
Depth (in feet)	6	15	21	21	21	18	15	..
Character of Bottom	Sand among Rocks	Sand	Mud	Algae	Algae	Sand	Sand	..
Distance from Shore (yds)	15	50	100	200	400	800	1000	..
Mollusca	4	15	6	8	12	25	15	85
Chironomidae	13	30	5	67	45	28	23	211
Trichoptera	1	8	..	..	..	4	..	13
Ephemeridae	4	3	..	1	..	5	4	17
Amphipoda	..	70	16	62	..	96	33	277
Oligochaeta	1	2	..	..	1	7	..	11
Nematoda	..	..	..	..	..	1	..	1
Hydracarina	..	..	..	..	..	6	..	6
Totals	23	128	27	138	58	172	75	621

NORTH SHAKESPEARE—HAT MOUNTAIN

Series XIII

Dredging	1	2	3	4	5	6	7	8	Totals
Depth (in feet)	3	15	18	24	33	57	63	69	..
Character of Bottom	Sand	Ooze	Mud	Ooze	Gravel & Sand	Mud	Mud	Mud	..
Distance from Shore (yds.)	15	80	130	430	530	730	900	1100	..
Mollusca	..	18	15	29	1	1	..	..	64
Chironomidae	3	59	46	98	32	10	28	3	279
Amphipoda	12	3	3	20	5	4	18	2	67
Oligochaeta	1	7	3	3	2	1	..	..	17
Nematoda	..	1	..	1	1	..	5	..	8
Trichoptera	..	2	4	1	..	..	..	..	7
Ephemeridae	..	..	..	1	1	..	..	..	2
Hydracarina	..	2	..	..	..	..	..	..	2
Totals	16	92	71	153	42	16	51	5	446

McL. BAY — Series XIV

									Totals
Dredging	1	2	3	4	5	6	7	8	..
Depth (in feet)	3	3	6	6	9	15	30	36	..
Character of Bottom	Wood Debris & Mud	Mud	Mud	Mud	Mud	Mud	Sand	Clay	..
Distance from Shore (yds.)	15	40	75	150	200	250	350	450	..
Mollusca	4	7	33	15	85	2	..	..	146
Chironomidae	7	..	30	2	49	6	7	3	104
Amphipoda	..	..	3	..	..	..	..	1	4
Oligochaeta	20	..	4	..	27	4	..	3	58
Nematoda	3	..	1	..	..	..	..	..	4
Tabanidae	2	..	..	..	..	..	..	..	2
Ephemeridae	..	3	2	3	2	..	..	..	10
Trichoptera	1	..	..	1	2	..	..	..	4
Hirudinea	1	..	..	..	..	..	..	..	1
Hydracarina	..	..	2	..	..	..	..	..	2
Neuroptera	..	..	1	..	..	..	..	..	1
Acanthocephala	..	..	..	..	..	..	..	7	7
Totals	38	10	76	21	165	12	7	14	343

FOOT OF ORIENT BAY

Series XV

Dredging	1	2	3	4	5	6	7	8	9	10	Totals
Depth (in feet)	12	3	2	5	3	5	9	69	51	27	..
Character of Bottom	Gravel	Sand	Sand	Sand	Sand	Sand	Sand	Mud	Mud	Mud	..
Distance from Shore (yds.)	..	100	200	300	400	550	700	800	900	1000	..
Mollusca	3	..	..	10	11	5	32	5	..	13	79
Chironomidae	..	2	1	3	4	11	11	53	27	15	127
Amphipoda	..	..	..	..	1	..	..	1	1	10	13
Oligochaeta	..	..	..	..	5	2	3	1	2	1	14
Nematoda	..	..	..	..	..	..	2	..	..	1	3
Ostracoda	..	..	..	..	..	..	1	2	..	..	3
Ephemeridae	..	1	..	1	..	1	1	..	..	..	4
Trichoptera	..	2	..	..	1	2	..	..	..	..	5
Totals	3	5	1	14	22	21	50	62	30	40	248

BLACKWATER BAY — Series XVI

Dredging	1	2	3	4	5	6	7	8	9	Totals
Depth (in feet)	12	21	21	21	39	90	117	147	178	..
Character of Bottom	Sand	Mud & Gravel	Mud & Gravel	Mud & Gravel	Mud	Clay	Mud	Mud	Mud	..
Distance from Shore (yds.)	50	150	250	350	450	550	650	750	1000	..
Mollusca	..	1	..	4	7	2	..	..	..	14
Chironomidae	3	8	9	3	8	9	6	6	8	60
Trichoptera	..	..	..	..	1	..	..	..	..	1
Amphipoda	..	..	4	..	..	36	44	19	12	115
Oligochaeta	..	..	..	..	..	3	..	3	3	9
Nematoda	..	..	1	..	..	..	..	2	2	5
Hydracarina	..	..	..	..	..	..	1	..	..	1
Ostracoda	..	..	..	..	..	2	..	3	..	5
Totals	3	9	14	7	16	52	51	33	25	210

SECOND CHANNEL W. OF NIPIGON RIVER — Series XVII

Dredging	1	2	3	4	5	6	7	8	Totals
Depth (in feet)	18	18	12	12	12	3	27	28	..
Character of Bottom	Mud	Mud	Mud	Mud	Mud	Sand	Gravel	Mud & Sand	..
Distance from Shore (yds.)	25	75	150	250	350	550	750	1150	..
Mollusca	5	12	19	26	15	7	33	1	118
Chironomidae	35	37	55	17	18	154	9	12	337
Ephemeridae	6	4	5	6	2	8	4	..	35
Trichoptera	..	1	7	..	..	1	3	2	14
Amphipoda	3	..	9	6	..	..	6	2	26
Oligochaeta	4	8	4	..	8	9	1	7	41
Ostracoda	..	..	..	..	3	1	..	..	4
Hirudinea	..	1	1	..	..	1	1	..	4
Hydracarina	..	..	1	..	..	2	..	..	3
Neuroptera	..	..	1	1	..	..	..	..	2
Coleoptera	..	..	..	1	..	1	..	..	2
Totals	53	63	102	57	46	184	57	24	586

SOUTH BAY (West Shore)	Series XVIII				SOUTH BAY (West Shore)	Series XIX			Totals
Dredging	1	2	3	4	1	2	3	4	..
Depth (in feet)	1½	3	6	6	2	4	5	5	..
Character of Bottom	Sand	Sand	Mud & Gravel	Mud & Gravel	Mud & Sand	Mud	Mud	Mud	..
Distance from Shore (yds.)	25	50	75	200	15	25	40	65	..
Mollusca	..	..	24	10	45	15	24	6	124
Chironomidae	50	3	22	40	35	2	25	10	187
Trichoptera	..	..	..	..	2	..	2	..	4
Amphipoda	..	1	3	5	..	..	2	1	12
Ostracoda	..	..	4	..	..	..	..	..	4
Oligochaeta	5	..	7	9	14	1	5	5	46
Nematoda	1	..	..	..	..	..	..	..	1
Hirudinea	..	..	2	..	..	..	..	1	3
Hydracarina	..	..	6	1	..	..	..	..	7
Cladocera	1	..	..	..	..	..	..	..	1
Coleoptera	..	..	..	..	..	..	..	1	1
Tabanidae	1	..	..	..	1	1	..	..	3
Totals	58	4	68	65	97	19	58	24	393

SECOND BAY WEST OF NIPIGON RIVER — Series XX

Dredging	1	2	3	4	5	6	7	8	9	Totals ..
Depth (in feet)	5	18	18	33	33	33	12	6	5	..
Character of Bottom	Mud	Mud	Mud	Mud	Mud	Mud	Mud	Mud	Mud	..
Distance from Shore (yds.)	15	50	150	250	300	350	400	450	550	..
Mollusca	23	2	2	..	..	..	11	11	..	49
Chironomidae	159	24	38	41	31	23	47	28	12	403
Ephemeridae	5	1	..	..	..	..	9	9	1	25
Trichoptera	1	..	..	..	..	..	2	..	..	3
Amphipoda	10	3	16	36	42	34	2	2	..	145
Ostracoda	4	..	..	..	1	..	..	..	..	5
Oligochaeta	12	5	..	5	7	2	1	4	1	37
Nematoda	1	..	..	4	2	..	..	..	..	7
Hirudinea	3	..	..	..	1	..	..	..	..	4
Hydracarina	7	1	..	..	..	..	..	1	..	9
Coleoptera	1	..	..	..	..	..	..	..	..	1
Totals	226	36	56	86	84	59	72	55	14	688

BEAR CREEK — Series XXI

							Totals
Dredging	1	2	3	4	5	6	..
Depth (in feet)	18	9	9	9	9	9	..
Character of Bottom	Mud	Mud & Debris	Sand & Debris	Sand	Sand	Sand	..
Distance from Shore (yds.)	20	300	600	900	1300	1700	..
Mollusca	1	2	..	..	..	1	4
Chironomidae	5	2	..	..	7	1	15
Ephemeridae	..	..	..	..	..	1	1
Trichoptera	..	1	1	..	1	..	3
Ostracoda	..	..	..	..	4	..	4
Oligochaeta	..	..	..	..	12	1	13
Totals	6	5	1	0	24	4	40

NORTH SHAKESPEARE BAY — Series XXII

Dredging	1	2	3	4	5	6	7	8	9	Totals
Depth (in feet)	4	18	18	36	24	15	9	6	2½	..
Character of Bottom	Mud	Mud	Mud & Gravel	Mud	Mud	Mud	Mud	Sand	Sand	..
Distance from Shore (yds.)	10	60	110	210	610	710	760	810	840	..
Mollusca	47	5	2	6	..	3	8	36	..	107
Chironomidae	15	27	13	2	8	26	15	6	46	158
Trichoptera	2	2	..	..	..	..	..	..	..	4
Ephemeridae	8	3	2	..	1	6	4	9	1	34
Amphipoda	1	3	3	1	11	2	..	1	..	22
Oligochaeta	4	3	1	..	1	..	3	..	2	14
Nematoda	..	..	2	..	..	..	..	..	1	3
Hirudinea	2	..	..	..	..	..	..	1	..	3
Hydracarina	..	..	..	1	1	1	2	..	..	5
Odonata	..	..	..	..	..	1	..	..	..	1
Tabanidae	..	..	..	..	..	..	..	..	1	1
Totals	79	43	23	10	22	39	32	53	51	352

NORTH SHAKESPEARE ISLANDS — Series XXIII

Dredging	1	2	3	4	5	6	7	8	Totals ..
Depth (in feet)	5	17	21	21	15	9	42	42	..
Character of Bottom	Gravel among Rocks	Sand	Sand	Sand	Sand	Sand	Mud	Mud	..
Distance from Shore (yds.)	10	40	40	60	100	130	230	380	..
Mollusca	2	15	1	..	..	60	..	3	81
Chironomidae	5	16	9	12	3	7	4	13	69
Ephemeridae	9	6	1	..	1	6	..	..	23
Trichoptera	1	1	..	2	..	6	..	..	10
Coleoptera	..	..	..	1	..	..	1	1	3
Neuroptera	..	1	..	..	..	..	..	..	1
Oligochaeta	1	1	1	1	..	..	3	..	7
Hirudinea	..	..	6	1	..	1	..	..	8
Hydracarina	..	..	1	..	..	2	..	..	3
Amphipoda	1	2	6	5	..	13	7	8	42
Totals	19	42	25	22	4	95	15	25	247

ORIENT BAY (At Macdiarmid) Series XXIV

										Totals
Dredging	1	2	3	4	5	6	7	8	9	..
Depth (in feet)	6	39	90	150	87	69	63	11	9	..
Character of Bottom	Sand	Mud	Mud	Mud	Mud	Mud	Clay	Sand & Clay	Mud	..
Distance from Shore (yds)	10	30	60	160	800	1000	1100	1500	1700	..
Mollusca	9	2	..	..	..	2	5	15	7	40
Chironomidae	8	3	1	5	2	13	5	7	7	51
Ephemeridae	3	1	..	..	..	..	..	..	..	4
Amphipoda	..	4	67	61	32	21	28	..	..	213
Oligochaeta	7	..	..	6	2	5	3	8	10	41
Nematoda	..	1	..	1	..	2	1	..	..	5
Hirudinea	1	..	..	..	..	..	..	..	..	1
Hydracarina	..	..	1	..	..	..	..	..	..	1
Totals	28	11	69	73	36	43	42	30	24	356

NAONAN IDS.	Series I	NIPIGON HOUSE	Series VII		MACDIARMID HARBOUR		Series XXV	
								Totals
Dredging	1	1	2	3	1	2	3	..
Depth (in feet)	150 (?)	144	36 (?)	..	9	8	5	..
Character of Bottom	Mud & Shells	Clay	Mud	..	Mud	Mud	Mud	..
Distance from Shore (yds.)	800	800	125	..	100	75	25	..
Mollusca	..	..	3	..	37	3	2	45
Chironomidae	3	11	10	..	42	39	9	114
Trichoptera	..	..	..	..	1	..	..	1
Ephemeridae	..	..	8	..	..	..	..	8
Amphipoda	13	47	9	..	7	..	2	78
Oligochaeta	3	..	..	..	28	17	6	54
Nematoda	..	..	1	..	..	1	..	2
Hirudinea	..	..	..	..	1	..	..	1
Cladocera	..	..	..	..	..	..	1	1
Hydracarina	..	..	..	..	..	1	..	1
Totals	19	58	31	..	116	61	20	305

ORIENT BAY AND NORTHWARD (East Shore) Series XXVI

Dredging	1	2	3	4	5	6	7	8	9	Totals ..
Depth (in feet)	9	18	8	12	18	24	27	48	129	..
Character of Bottom	Sand	Sand	Sand	Sand	Gravel	Sand	Sand	Sand	Mud	..
Distance from Shore (yds)	30	60	85	130	230	280	330	380	430	..
Mollusca	8	6	1	..	..	..	1	4	..	20
Chironomidae	9	6	46	4	2	2	6	6	5	86
Trichoptera	..	1	..	..	..	..	..	..	..	1
Amphipoda	..	..	..	2	..	..	..	..	45	47
Ostracoda	..	..	2	..	..	..	..	..	..	2
Oligochaeta	8	14	22	..	1	3	2	8	14	72
Nematoda	..	..	..	..	..	..	1	..	..	1
Totals	25	27	71	6	3	5	10	18	64	229

VIRGIN ISLANDS — Series XXVII

Dredging	1	2	3	4	5	6	7	8	9	Totals
Depth (in feet)	6	12	15	15	15	12	9	5	3	..
Character of Bottom	Sand	Sand	Sand	Sand	Sand	Mud on Sand	Mud on Sand	Mud on Sand	Mud	..
Distance from Shore (yds)	10	50	100	150	200	300	400	500	600	..
Mollusca	96	14	1	3	10	12	10	31	213	390
Chironomidae	48	1	9	..	15	28	32	49	43	225
Trichoptera	2	1	..	..	..	2	..	..	1	6
Ephemeridae	7	..	..	..	1	1	..	7	..	16
Amphipoda	..	..	..	..	1	..	..	..	..	1
Ostracoda	..	..	..	..	..	..	..	1	..	1
Oligochaeta	21	3	2	3	5	2	10	5	12	63
Nematoda	..	..	..	..	..	..	..	..	3	3
Hirudinea	7	..	..	..	..	..	..	..	2	9
Hydracarina	2	..	..	1	..	1	..	1	4	9
Totals	183	19	12	7	32	46	52	94	278	723

McINTYRE BAY (South End) Series XXVIII

										Totals
Dredging	1	2	3	4	5	6	7	8	9	..
Depth (in feet)	1	3	9	12	15	18	21	24	24	..
Character of Bottom	Sand	Mud on Sand	Mud & Gravel	Mud & Sand	Mudon Sand	Mud	Mud	Mud	Mud	..
Distance from Shore (yds)	25	75	125	175	225	325	425	525	625	..
Mollusca	4	1	17	12	6	6	6	3	8	63
Chironomidae	8	21	3	2	..	14	1	2	16	67
Trichoptera	..	1	1	1	..	..	1	..	..	4
Ephemeridae	..	1	2	3	..	3	1	1	..	11
Amphipoda	1	..	2	5	12	9	27	5	1	62
Oligochaeta	1	2	..	..	2	..	7	3	2	17
Hirudinea	..	..	..	..	1	..	..	..	..	1
Hydracarina	..	..	..	..	..	..	..	..	2	2
Odonata	..	..	..	..	2	..	..	..	..	2
Totals	14	26	25	23	23	32	43	14	29	229

McINTYRE BAY (East Side among Islands) Series XXIX

Dredging	1	2	3	4	5	6	7	8	Totals
Depth (in feet)	3	6	12	18	18	21	21	15	..
Character of Bottom	Mud	Mud	Mud	Mud	Mud	Mud	Mud	Mud	..
Distance from Shore (yds.)	10	60	110	160	210	260	310	360	..
Mollusca	16	8	3	3	6	10	5	9	60
Chironomidae	14	11	23	22	38	40	100	4	252
Trichoptera	2	..	..	..	..	..	..	1	3
Ephemeridae	2	2	2	2	7	7	6	6	34
Coleoptera	..	1	..	..	..	..	..	..	1
Neuroptera	..	..	..	1	2	1	2	..	6
Amphipoda	3	..	3	10	9	31	12	2	70
Oligochaeta	6	..	4	1	..	6	6	1	24
Nematoda	..	..	..	2	..	..	1	..	3
Ostracoda	..	..	..	..	..	1	9	..	10
Hydracarina	..	..	..	..	1	..	..	..	1
Totals	43	22	35	41	63	96	141	23	464

McINTYRE BAY (North End) Series XXX

							Totals
Dredging	1	2	3	4	5	6	..
Depth (in feet)	6	9	9	21	45	48	..
Character of Bottom	Mud	Mud	Mud	Mud	Mud	Mud	..
Distance from Shore (yds.)	30	80	130	180	230	280	..
Mollusca	47	17	9	2	2	..	77
Chironomidae	6	15	5	2	9	1	38
Trichoptera	2	3	..	..	..	..	5
Ephemeridae	10	7	3	5	1	..	26
Amphipoda	3	7	4	1	105	30	150
Oligochaeta	6	3	..	1	3	9	22
Ostracoda	..	1	..	..	..	..	1
Odonata	..	4	1	..	1	..	6
Hydracarina	1	1	..	..	..	..	2
Hirudinea	1	..	..	..	..	..	1
Cladocera	..	1	..	..	..	..	1
Coleoptera	..	..	1	..	..	..	1
Neuroptera	..	1	..	..	..	..	1
Totals	76	60	23	11	121	40	331

GROS CAP	Series XXXI					ALEXANDER ID. Series XXXII				
										Totals
Dredging	1	2	3	4	5	1	2	3	4	..
Depth (in feet)	3	9	15	24	30	1	4	6	9	..
Character of Bottom	Mud	Mud	Mud	Mud	Mud	Mud	Sand	Sand	Sand	..
Distance from shore (yds.)	10	35	60	110	210	10	25	50	100	..
Mollusca	38	38	5	5	..	3	50	52	20	211
Chironomidae	18	38	121	24	5	15	40	44	26	331
Trichoptera	1	3	3	..	..	..	..	2	..	9
Ephemeridae	6	1	1	2	1	..	2	3	3	19
Amphipoda	1	7	10	..	2	..	..	10	6	36
Ostracoda	1	..	6	..	..	..	..	2	2	11
Oligochaeta	3	3	5	3	1	2	4	21	5	47
Nematoda	..	..	..	..	..	..	6	..	..	6
Hydracarina	..	..	..	..	..	..	..	2	1	3
Hirudinea	..	..	..	..	..	..	..	..	1	1
Neuroptera	..	..	..	..	..	..	..	1	..	1
Cladocera	..	..	..	..	..	..	1	..	..	1
Coleoptera	2	..	..	..	..	..	..	..	..	2
Totals	70	90	151	34	9	20	103	137	64	678

UNIVERSITY OF TORONTO STUDIES

PUBLICATIONS OF THE
ONTARIO FISHERIES RESEARCH LABORATORY
No. 16

THE FOOD OF LAKE NIPIGON FISHES

BY

WILBERT A. CLEMENS
JOHN R. DYMOND
N. K. BIGELOW
F. B. ADAMSTONE
AND
W. J. K. HARKNESS
OF THE DEPARTMENT OF BIOLOGY
UNIVERSITY OF TORONTO

TORONTO
THE UNIVERSITY LIBRARY
1923

THE FOOD OF LAKE NIPIGON FISHES

In conjunction with the various studies dealing with the food supply of fish in Lake Nipigon as well as with the studies of the distribution and rates of growth of the fish themselves, examinations of the contents of a considerable number of alimentary tracts of several species of fish have been made. The results, as far as it has been possible to bring them together at the present time, are given in the following tables. In the cases of the larger predaceous fish (lake trout, yellow pike perch, and ling), the numbers in the columns give the actual number of fish eaten and a + sign indicates material disintegrated beyond identification and no attempt made to count individuals. In the tables dealing with the other species an attempt has been made to estimate the percentages of the most abundant organisms found, and the numbers in the tables give these estimates. A + sign in these tables indicates occurrence in amounts not estimated, usually representing less than one per cent. The results of the examination of 455 fish are given, distributed as follows:— sturgeon 12, northern sucker 16, common sucker 33, minnows 27, round whitefish 29, common whitefish 65, ciscoes 89, lake trout 42, trout perch 23, small mouth black bass 6, yellow pike perch 20, yellow perch 14, ling 79.

STURGEON. *Acipenser rubicundus*

No.	Date 1921	Length in cm.	*Ephemeridae* nymphs	*Chironomidae* larvae	*Mollusca*	Fish remains	Miscellaneous
1	July 12	44.0	+	+	..	98	Misc. 2 (*Ephemeridae* nymph, *Trichoptera* larva, Dytiscid larva, *Chironomidae* larvae and pupae, Tabanid larva).
1	June 24	44.0	24[1]	+	+	75	Misc. 1 (*Trichoptera* larva, *Chironomidae* larvae, *Mollusca*, *Cladophora*).
1	June 24	54.0	..	65	1	1	*Pontoporeia hoyi* 30; misc. 3 (*Hydracarina*, *Corixa*, *Trichoptera* larvae and pupa, *Coleoptera*).
1	June 23	large	..	..	100	..	
1	" 23	"	2[2]	2	85	3	Misc. 8 (*Pectinatella* statoblast, *Amphipoda*, *Odonata* nymph, *Corixa*, *Trichoptera* larvae, *Chironomidae* adult, *Nostoc*, *Ulothrix*, *Cladophora*, *Chara*, *Bryophyta*, higher plant tissues).
1	" 23	"	5	40	50	..	Misc. 5 (*Amphipoda*, *Trichoptera* larvae).
1	" 23	"	..	+	70	30	*Cyclops*.
1	July 9	"	4	1	75	20	
1	Aug. 26	"	98[3]	+	2	..	
1	" 26	"	99	+	+	..	*Cladophora*.
1	" 26	"	95	4	..	..	*Cladophora*.
1	" 26	"	99	+	..	..	*Bosmina longirostris*, *Diatoms*, *Ulothrix*, *Cladophora*.

[1] *Ephemera simulans*.
[2] *Hexagenia bilineata*, *Ephemera simulans*, *Heptagenia tripunctata*.
[3] *Ephemera simulans*.

NORTHERN SUCKER. *Catostomus catostomus*

No.	Date 1921	Length in cm.	*Pontoporeia hoyi*	*Trichoptera* larvae	*Chironomidae* larvae	*Chironomidae* pupae	*Mollusca*	Miscellaneous
6	July 28	12–16	..	10	50	5	10	Misc. 25 (*Bryozoa, Canthocamptus, Bosmina longirostris, Camptocercus, Acroperus harpae, Alona affinis, A. quadrangularis, Chydorus sphaericus, Alonella nana, A. rostrata, Ostracoda, Hyallela knickerbockerii, Hydracarina, Thysanura*).
1	July 15	17.0	15	..	70	10	1	Misc. 4 (*Difflugia, Plumatella, Canthocamptus hiemalis, Alona affinis, Chydorus sphaericus, Ostracoda, Hydracarina, Diatoms*).
1	June 14	22.5	90	..	9	..	1	
1	" 28	24.5	96	..	1	..	2	Misc.1 (*B osmina*, etc.).
1	" 24	27.0	90	10	..	..	..	*Diatoms*.
1	" 28	29.0	..	..	..	..	..	Filamentous *Algae* 60; *Diatoms* 30; Insecta fragments 10.
1	July 4	34.2	30	..	5	5	+	*Hyallella knickerbockerii* 10; other forms 50 (*Arcella, Centropyxis, Cyclops, Ostracoda, Hydracarina*, filamentous *Algae, Diatoms*).
1	July 21	40.5	15	..	85	+	..	
1	June 24	42.2	80	..	18	..	+	Misc. 2 (*Hydracarina*, two *Plecoptera* nymphs, *Chironomidae* adult, *Diatoms*).
2	July 15	?	..	+	70	+	20	Misc. 10 *Rhizopoda, Cyclops, Chydorus sphaericus, Ostracoda, Corixa, Ulothrix, Cladophora, Diatoms*).

COMMON SUCKER, *Catostomus commersonii*

No.	Date 1921	Length in cm.	*Pontoporeia hoyi*	*Trichoptera* larvae	*Chironomidae* larvae	*Chironomidae* pupae	*Mollusca*	Miscellaneous
1	June 11	13.2	..	45	35	5	1	*Ostracoda* 2; *Hydracarina* 5; other forms 7 (*Cyclops*, *Canthocamptus*, *Alona affinis*, *Chydorus sphaericus*, *Hyallela knickerbockerii*, *Diatoms*).
2	July 12	13.0-13.5	..	..	82	2	10	Misc. 6 (*Canthocamptus*, *Eurycercus lamellatus*, *Acroperus harpae*, *Alona affinis*, *Chydorus sphaericus*, *Ostracoda*, *Hydracarina*, *Corixa*, *Ulothrix*, *Bulbochaete*, *Diatoms*).
1	July 21	15.0	..	45	20	..	30	Misc. 5 (*Centropyxis*, *Canthocamptus*, *Alona quadrangularis*, *Chydorus sphaericus*, *Ostracoda*, *Hydracarina*, *Diatoms*).
5	June 11	25-30	..	5	40	3	12	*Hyallela knickerbockerii* 35; other forms 5 (*Cyclops*, *Canthocamptus*, *Plecoptera* nymphs, *Ephemeridae* nymphs, *Corixa*, *Diatoms*).
1	July 12	26.0	1	55	35	+	5	Misc. 4 (*Canthocamptus*, *Bosmina*, *Eurycercus lamellatus*, *Alona affinis*, *Ostracoda*, *Hydracarina*, *Corixa*, *Chironomidae* pupae, *Ulothrix*, *Diatoms*).
8	July 28	26.0 app.	50	1	30	10	5	*Hydracarina* 4; *Ephemeridae* nymph (*Caenis*).
2	Aug. 4	37-41	90	..	5	+	4	Misc. 1 (*Hydracarina*, *Chironomus* pupa).

The stomach contents of a large number of small suckers have been examined. The following list of organisms found in 13 specimens, averaging 2.8 cm. in length, taken July 27 in a seine, will illustrate the type of food and the variety of forms found:

Algae—Oscillatoria, Melosira, Pinnularia, Navicula, Stauroneis, Amphora, Cocconema, Achnanthes, Surirella, Epithemia, Desmidium, Closterium, Docidium, Staurastrum, Micrasterias, Euastrum, Cosmarium, Oöcystis.

Protozoa—Arcella, Centropyxis, Lecquereusia, Difflugia, Cyphoderia, Sphenoderia, Euglypha.

Rotatoria—Keratella cochlearis, Euchlanis, Lecane luna, Lecane leontina, Lecane sp., *Monostyla lunaris, Trichocera, Gastropus stylifer.*

Oligochaeta—podal spines.

Copepoda—Cyclops.

Cladocera—Latona setifera, Daphnia, Bosmina longirostris, Eurycercus lamellatus, Kurzia latissima, Acroperus harpae, Alona guttata, A. affinis, Graptoleberis testudinaria, Rynchotalona falcata, Pleuroxus denticulatus, Chydorus sphaericus, Alonella nana, A. excisa, A. exigua, Monospilus dispar.

Ostracoda—several species.

Hydracarina—

Insecta—Ephemeridae nymph, *Chironomidae* larvae, dipterous pupae.

MINNOWS—(*Cyprinidae*)

Spot-tail minnow, *Notropis hudsonius*

Twelve individuals, 5 to 7 cm. in length, were taken, on July 20, in a seine close to the dock at the village of Macdiarmid.

Bryozoa—one statoblast, probably of *Pectinatella.*

Cladocera—a few *Bosmina longirostris, Acroperus harpae, Alona* sp., many *Chydorus sphaericus*, a few *Polyphemus pediculus.*

Ostracoda—fragments.

Arachnida—one water-mite and two spiders.

Insecta—one mayfly nymph, one mayfly subimago, a few *Corixa* nymphs, several chironomid pupae and adults.

Mollusca—Snail shell fragments.

Couesius plumbeus

Fifteen individuals, 4.2 to 7.4 cm. in length, were taken on July 20, in a seine close to the dock at the village of Macdiarmid.

Cladocera—considerable numbers of *Chydorus sphaericus*.

Insecta—one ephemerid or plecopteran nymph, corixids, one beetle, one chironomid larva, one chironomid adult, one *Lucillia caesar*, several ants.

ROUND WHITEFISH. *Coregonus quadrilateralis*

No.	Date 1921	Length in cm.	*Trichoptera* larvae	*Chironomidae* larvae	*Chironomidae* pupae	*Mollusca*	Miscellaneous
2	Aug. 4	5.0–5.3	1	1	95	..	*Corixa* nymphs 1; *Ephemeridae* nymphs 1.
1	June 28	16.0	..	20	10	5	*Mysis relicta* 30; *Pontoporeia hoyi* 10; *Corixa* 15; other forms 10 (*Ostracoda*, *Hydracarina*, small beetle, filamentous *Algae*).
1	July 15	16.5	35	20	20	20	*Chironomidae* adults 5; *Ostracoda*.
1	June 14	17.5	4	30	65	1	
1	" 24	18.0	..	35	65	..	
1	July 15	18.3	85	..	7	8	
3	Aug. 5	18.0 app.	10	80	5	..	*Ostracoda* 5; small *Homoptera; Algae.*
18	" 8	17–19	95	1	+	1	Other forms 3 (*Cyclops*, *Daphnia pulex*, *Bosmina*, *Drepanothrix*, *Alona affinis*, *A. quadrangularis*, *A. costata*, *Eurycercus lamellatus*, *Acroperus harpae*, *Chydorus sphaericus*, *Ostracoda*, *Hydracarina*, *Trichoptera* pupa, filamentous *Algae*, *Diatoms*).
1	June 24	21.1	65	11	..	20	*Ephemeridae* nymphs (*Ephemerella*) 2; *Odonata* nymph 1; *Hemiptera* 1.

COMMON WHITEFISH, *Coregonus clupeaformis*

No.	Date 1921	Length in cm.	*Ostracoda*	*Pontoporeia hoyi*	*Hydracarina*	*Trichoptera* larvae	*Chironomidae* larvae	*Chironomidae* pupae	*Mollusca*	Miscellaneous
2	Aug. 4	4.8-5.8	..	..	25	10	5	..	..	*Chironomidae* adults 50; other forms 15 (*Cyclops*, *Bosmina longirostris*, *Acroperus harpae*, *Arachnida*, *Hemiptera Coleoptera*, *Formicina*).
1	July 6	14.0	+	..	+	..	80	10	6	Misc. 4 (*Bosmina longirostris Corixa*).
1	" 15	14.3	..	..	7	..	80	3	5	Misc. 5 (*Plumatella*, *Amphipoda*, *Plecoptera* nymph, *Melosira*).
3	" 28	15.0 app.	..	..	10	..	20	20	20	*Hemiptera* 5; *Ephemeridae* nymphs (*Caenis*) 5; *Chironomidae* adults 20.
3	Aug. 27	15.0 app.	1	..	3	..	2	2	1	*Mysis relicta* 90; other forms 1 (*Diaptomus*, *Cyclops*, *Canthocamptus*, *Latona setifera*, *Bosmina longirostris*).
1	June 14	16.0	98	..	+	..	..	2	+	
1	Aug. 5	16.0 app.	+	..	2	..	95	+	2	Misc. 1 (*Hemiptera*, dipterous adult).
4	Aug. 8	16.2 app.	..	..	4	1	1	1	93	*Bosmina longirostris*.
1	July 4	16.5	100	..	..	..	..	..	..	
1	" 15	17.5	+	..	30	..	45	..	25	
18	" 21	15-18	+	+	+	15	10	5	10	*Ephemeridae* nymphs (*Hexagenia*, *Caenis*) 45; *Corixa* 5; *Trichoptera* pupae 5; other forms 5 (*Cyclops*, *Bosmina*, *Insecta* fragments, *Cladophora*, *Diatoms*).
1	" 4	25.7	..	15	..	..	80	..	5	

COMMON WHITEFISH—*Cont.*

No.	Date 1921	Length in cm.	*Ostracoda*	*Pontoporeia hoyi*	*Hydracarina*	*Trichoptera* larvae	*Chironomidae* larvae	*Chironomidae* pupae	*Mollusca*	Miscellaneous
6	July 28	25-27	..	2	+	..	2	50	+	One *Leucichthys* (cisco) 45; Misc. 1 (*Canthocamptus; Corixa*).
1	June 30	28.0	..	30	..	..	70	..	..	*Coleoptera* adult, *Chironomidae* adult.
10	July 26	34.0 app.	..	35	+	..	60	..	1	Misc. 4 (*Mysis relicta, Formicina*).
1	June 14	35.3	..	..	1	2	2	..	15	One *Pygosteus pungitius* (nine-spined stickleback) and other fish remains 75; other forms 5 (*Plumatella, Ephemeridae* nymph, *Corixa, Cladophora, Diatoms*).
1	" 24	36.5	..	80	1	..	4	..	15	*Canthocamptus hiemalis, Diaptomus sicilis.*
1	July 12	36.5	..	52	1	..	5	..	40	*Algae* and higher plants 2.
1	June 20	37.2	..	50	..	..	40	..	10	
1	July 12	38.5	..	25	3	..	25	3	40	*Ephemeridae* nymphs (*Heptagenia*) 4.
1	Aug. 12	39.3	..	..	..	..	..	..	5	Four *Pygosteus pungitius* (nine-spined sticklebacks) and other fish remains 95.
1	Aug. 4	40.0	..	..	..	..	+	..	+	Two Miller's Thumbs and one other fish unident. 98; *Ephemeridae* nymphs 1.
1	June 20	42.0	..	..	..	..	..	..	17	*Hemiptera* 4; *Coleoptera* 45; *Diptera* 4; *Formicina* 30.
1	July 15	45.0	..	..	+	..	..	..	99	Misc. 1 (*Rotatoria, Bosmina longirostris, Plecoptera* nymph, *Ephemeridae* nymphs (*Heptagenia*) *Corixa*, dipterous adult, *Diatoms*).
1	July 15	?	..	..	+	..	+	..	99	*Diatoms.*
1	Aug. 6	?	..	4	..	..	92	..	..	*Coleoptera* 4.

CISCOES, *Leucichthys*

No.	Date 1921	Length in cm.	*Limnocalanus macrurus*	*Lepidodora kindtii*	*Mysis relicta*	*Chironomidae* larvae	*Chironomidae* pupae	Miscellaneous
12	July 6	12-17	..	..	55	25	10	Misc. 10 (*Cyclops*, *Amphipoda*, *Hydracarina*, *Ephemeridae* (*Ephemerella* nymphs, *Heptagenia* subimago), *Corixa*, *Trichoptera* adult, dipterous adult.
1	" 6	14.5	..	..	99	1	..	
1	Aug. 12	14.5	..	55	1	..	..	*Diaptomus* 10; *Cyclops* 30; other forms 4 (*Daphnia longispina*, *Bosmina longirostris*, *Chydorus sphaericus*, *Hydracarina*, dipterous adults).
1	June 11	14.8	..	..	..	..	97	Misc. 3 (*Hydracarina*, Chalcid, *Formicina*).
1	" 30	14.8	..	..	95	..	..	Misc. 5 (*Bryozoa*, *Hymenoptera*, *Mollusca*, *Diatoms*).
1	" 11	15.2	..	..	..	..	100	
1	" 30	15.2	..	..	100	..	..	
14	July 26	16.0 app.	..	..	100	..	..	
2	Aug. 4	16.0 app.	..	90	..	5	5	*Cyclops*.
1	June 20	16.1	5	..	95	..	..	
1	July 4	16.5	..	..	99	1	..	
5	" 21	15-21	..	..	85	15	..	*Cyclops*.
20	" 20	16-25	..	..	99	1	..	*Mollusca*.
1	June 30	19.8	..	..	99	..	..	*Ostracoda* 1.
1	July 15	20.7	..	..	..	..	..	Fragments winged terrestrial insects 100 (*Ephemeridae*, *Hemiptera*, *Trichoptera*, *Lepidoptera*, *Coleoptera*, *Diptera*, *Hymenoptera*).
1	June 30	25.0	..	..	100	..	..	
1	" 30	26.0	..	..	100	..	..	
3	Aug. 21	28.5 app.	50	..	50	..	..	*Diaptomus*.
1	June 30	29.8	5	..	95	..	..	One small caterpillar.
4	July 4	28-31	98	..	2	+	..	
2	" 21	29.3-30.5	90	..	5	5	..	
1	June 30	30.0	75	..	25	..	..	
1	July 4	31.0	50	..	50	..	..	
11	" 26	31.0 app.	5	..	95	..	..	
1	June 30	45.0	10	..	90	..	..	

LAKE TROUT, *Cristovomer namaycush*

No.	Date 1921	Length in cm.	Ciscoes	Nine-spined stickle-backs	Trout perch	Miller's Thumbs	Ling	Fish remains
1	June 14	20.0	1 (6.5 cm.)	..	..	..	..	..
1	"	22.0	4 (6.5 cm.)	..	..	..	..	..
1	"	23.0	1 (6.5 cm.)	..	..	..	..	..
1	" 28	31.2	..	..	..	..	..	+
1	July 4	36.0	6 (6-10 cm.)	..	..	..	..	..
1	June 14	36.5	..	4	..	..	..	..
1	" 24	48.5	3 (7-10 cm.)	..	..	..	..	..
1	July 4	50.0(?)	1 (10 cm.)	..	..	..	..	..
1	Aug. 12	53.0	..	1	..	..	..	..
1	" 10	60-80	1 (37 cm.)	..	..	..	..	..
1	"	"	2	1	..	..	..	..
1	"	"	1	..	..	..	..	..
1	"	"	1	1	..	..	..	..
1	"	"	1	..	..	..	..	..
1	"	"	1	..	..	..	..	..
1	"	"	1	..	..	..	..	..
1	"	"	1	..	..	..	..	..
1	"	"	1	..	..	..	..	..
1	"	"	1 (23 cm.)	..	..	..	..	..
1	"	"	1	..	..	..	..	..
1	"	"	1	..	..	..	..	..
1	"	"	..	..	..	2	..	..
1	"	"	2	..	..	..	..	..
1	"	"	1 (13 cm.)	..	..	..	..	..
1	"	"	1 (30 cm.)	..	..	..	..	..
1	"	"	1 (30 cm.)	..	..	..	..	..
1	"	"	3	..	..	..	..	..
1	"	"	..	..	..	..	1	..
1	"	"	1	..	..	..	..	..
1	"	"	1	..	..	..	..	..
1	"	"	2	..	..	..	..	..
1	"	"	1 ..	1	..	..	..	..
1	"	"	..	..	1	..	..	..
1	"	"	1	..	..	..	..	..
1	"	"	1 (23 cm.)	..	..	..	..	..
1	"	"	1	..	..	..	..	..
1	"	"	1	..	..	..	..	..
1	"	"	1	..	..	..	..	..
2	"	"	..	..	..	..	..	+
1	Aug. 22	90.0	..	..	..	..	1(37cm)	..
1	" 10	100.0	..	..	..	..	1(42cm)	..

TROUT PERCH, *Percopsis omisco maycus*

Food of 23 individuals 6.0-9.5 cm. in length were taken July 20 in a trap net set in the Pustagone river.

No.	*Ostracoda*	*Amphipoda*	*Ephemeridae* nymphs	*Trichoptera* larvae	*Chironomidae* larvae	*Chironomidae* pupae	Miscellaneous
1	..	..	1	45	45	..	*Corixidae* 9.
1	..	..	95	..	..	5	
1	..	..	95	5	..	..	
1	..	1	50	48	1	..	
1	..	..	100	..	..	..	
1	1	..	65	3	25	..	*Cladocera* (*Ophryoxus gracilis, Chydorus sphaericus*) Gyrinid larvae 1; Haliplid beetles 5.
1	..	..	100	..	..	..	
1	5	..	80	..	15	..	Algal filaments.
1	..	4	25	..	35	35	1 Dipterous larva.
1	..	..	75	..	25	..	
1	..	10	50	..	25	10	Algal filaments; *Cladocera* (*Alona* sp.?).
1	..	..	60	..	40	..	
1	..	..	60	..	5	..	*Plecoptera* nymphs 35.
1	..	..	50	..	50	..	
1	..	5	60	..	35	..	
1	..	..	50	50 (pupae)	..	..	
1	25	..	25	..	25	25	*Diatoms* (*Surirella, Navicula*).
1	..	..	45	..	45	10	*Diatoms* (*Surirella, Epithemia*).
1	10	..	30	30	15	15	
1	..	..	75	..	25	..	
1	..	..	75	..	..	25	
1	..	..	50	..	50	..	
1	..	..	50	..	50	..	
6 App.	+	+	+	+	+	+	*Cladocera* (*Eurycercus lamellatus*).

Two genera of *Ostracoda* were represented, namely, *Cypria* and *Candona*. Three genera of *Ephemeridae* were represented, namely *Ephemera, Heptagenia* snd *Tricorythus*. All small dipterous pupae have been considered as *Chironomidae*, although in some cases the fragmentary state made identification uncertain.

SMALL MOUTH BLACK BASS, *Micropterus dolomieu*

No.	Date 1921	Length in cm.	*Copepoda*	*Cladocera*		*Insecta*				Fish remains
			Epischura lacustris	*Sida crystallina*	*Eurycercus lamellatus*	*Ephemeridae* nymphs	*Corixidae*	*Chironomidae* larvae	*Chironomidae* pupae	
1	July 19	2.6	95	..	5	..	..	..	..	..
1	"	2.6	66	2	..	..	16	8	8	..
1	"	2.8	2	2	..	15	65	16	..	..
3	" 27	3.3	..	80	..	3	10	..	1	6

YELLOW PIKE PERCH, *Stizostedion vitreum*

No.	Date 1921	Length in cm.	Ciscoes	Nine-spined sticklebacks	Miller's Thumbs	Fish remains
1	Aug. 4	5.3	..	..	..	+
1	July 20	5.6	..	..	..	+
1	" 20	6.8	..	..	..	+
1	" 28	14.0	..	..	..	+
1	" 12	15.0	..	4	..	..
8	" 28	17.0	..	6	..	+
1	" 12	18.0	..	5	..	+
1	" 12	29.5	..	1	1	..
1	Aug. 8	43.7	..	2	..	+
1	" 12	44.0	..	1	..	..
1	July 28	47.3	..	3	..	..
2	" 15	50.0 (?)	1(7.0 cm.)	1	..	+

YELLOW PERCH, *Perca flavescens*

No.	Date 1921	Length in cm.	*Copepoda*			*Cladocera*					*Insecta*						
			Epischura	*Diaptomus*	*Cyclops*	*Daphnia*	*Bosmina*	*Chydorus*	*Lepiodora*	*Ostracoda*	*Ephemeridae* nymphs	*Corixidae*	*Chironomidae* larvae	*Chironomidae* pupae	*Chironomidae* adults	Dipterous pupae	Fish
1	Aug. 15	3.0	..	..	15	..	50	..	..	..	..	..	..	..	..	35	..
5	June 27	3.4	10	75	1	1	1	..	2	..	..	..	..	..	10	..	..
7	July 30	4.7-5.6	..	..	..	..	..	..	..	..	62[1]	37	..	1	..	..	..
1	" 20	7.8	..	+	+	..	..	+	..	+	..	..	+	+	..	..	99[2]

[1]The *Ephemeridae* nymphs were *Callibaetis* sp.?

[2]The fish were the nine-spined stickleback (*Pygosteus pungitius*).

LING, *Lota maculosa*

No.	Date 1921	Length in cm.	Suckers	Ciscoes	Nine-spined sticklebacks	Trout Perch	Miller's Thumbs	Fish remains	*Mysis relicta*	*Pontoporeia hoyi*	*Chironomidae* larvae
1	July 26	20.0	..	..	1	1	..	..	..	..	..
1	" 4	35.5	..	..	1	..	..	..	..	..	..
1	" 4	35.5	..	..	..	..	..	3%	95%	+	2%
1	Aug. 8	35-42	..	..	1	..	..	..	..	..	..
1	" 8	"	..	..	..	..	1	..	..	..	..
1	" 23	35-42	..	..	1	..	..	..	..	..	..
1	" 23	"	..	..	2	..	..	..	..	..	..
1	" 10	35-55	..	2	..	..	1	..	..	..	..
1	"	"	..	1	..	..	..	..	..	..	..
1	"	"	..	..	1	..	5	..	..	.	.
1	"	"	..	1	..	..	1	..	..	..	..
1	"	"	..	1	..	..	..	..	..	..	..
1	"	"	..	2	..	..	1	+	..	..	..
1	"	"	..	8	..	..	..	..	..	..	..
1	"	"	..	9 (one 30.5 cm.)	..	..	..	..	..	..	..
1	"	"	..	4	..	..	..	..	..	..	..
1	"	"	..	2 (10 and 30 cm.)	..	..	..	..	..	..	..
1	"	"	..	2	..	..	..	..	.	..	..
1	"	"	..	2	..	..	1	..	..	..	..
1	"	"	..	1 (25 cm.)	..	..	..	..	..	..	..
1	"	"	..	5	..	..	..	..	..	..	..
1	"	"	..	5	..	..	..	..	..	..	..
1	"	"	..	2	2	..	1	..	..	..	..
1	"	"	..	3	..	..	..	..	..	..	..
1	"	"	..	1 (30 cm.)	..	..	..	..	..	..	..
1	"	"	..	..	..	..	1	+	..	..	..
1	"	"	..	1	..	..	..	..	..	..	..
1	"	"	..	1	..	..	..	..	..	..	..
1	"	"	..	1	..	..	..	..	..	..	..
1	"	"	..	2 (30 and 40 cm.)	..	..	..	..	..	..	..
1	"	"	..	4	..	..	..	..	..	..	..
1	"	"	..	2	..	..	..	+	..	..	..
2	"	"	..	..	..	..	..	+	..	..	..

LING, *Lota maculosa* (continued)

No.	Date 1921	Length in cm.	Suckers	Ciscoes	Nine-spined sticklebacks	Trout Perch	Miller's Thumbs	Fish remains	*Mysis relicta*	*Pontoporeia hoyi*	*Chironomidae* larvae
1	Aug. 22-23	35-55	..	1 (23 cm.)	..	..	..	..	..	..	..
1	"	"	..	1 (20 cm.)	..	..	..	..	..	..	..
1	"	"	..	2	..	..	..	..	..	..	..
1	"	"	..	5	..	..	..	..	..	..	..
1	"	"	..	1	..	..	..	..	..	..	..
1	"	"	..	1	..	..	..	..	..	..	..
1	"	"	..	3	..	..	1	..	..	..	..
1	"	"	1	3	..	..	1	..	..	..	..
1	"	"	..	2	..	..	..	+	..	..	..
1	"	"	..	4	..	..	..	..	..	..	..
1	"	"	..	4	..	..	..	+	..	..	..
1	"	"	..	3	..	..	5	..	..	..	..
1	"	"	..	1	..	..	..	+	..	..	..
1	"	"	..	1	..	..	..	+	..	..	..
1	"	"	..	1	..	..	1	+	..	..	..
1	"	"	..	6	..	..	..	+	..	..	..
1	"	"	..	2	1	..	..	+	..	..	..
1	"	"	..	..	..	..	3	+	..	..	..
1	"	"	..	..	5	..	1	+	..	..	..
1	"	"	..	..	..	..	1	+	..	..	..
1	"	"	..	..	..	..	1	+	..	..	..
1	"	"	..	..	..	..	1	+	..	..	..
28	"	"	..	..	..	..	..	+	..	..	..
3	"	"	..	..	..	..	..	..	100%	..	..
1	"	48.3	..	..	..	..	..	10%	75%	10%	3%
1	July 4	large	..	3 (11 cm.)	..	..	..	..	..	..	..

Little need be added in amplification of the data given in the tables, but mention may be made of a few outstanding points.

1. Gill net records show that the northern sucker inhabits deeper water than does the common sucker. The food studies substantiate this fact, in that, as a rule, higher percentages of *Pontoporeia* occurred in the northern sucker than in the common. It appears also that the older individ-

uals of the common sucker feed at greater depths than do the younger.

2. Somewhat similar conclusions may be drawn respecting the whitefishes. According to the gill net records, the round whitefish does not extend to as great depths as does the common whitefish, and its food, according to the table, is obtained in comparatively shallow water. The data do not show definitely that the older individuals of the common whitefish feed altogether at greater depths than do the younger. This would be expected where the data is not extensive, because large individuals are often taken in shallow water. It is evident that the common whitefish has serious competitors for food in the suckers, since the latter are bottom feeders and are very abundant in the lake.

3. The ciscoes, although very abundant, come into very little competition with other fish as regards food, in that they are open water plankton feeders, subsisting largely upon *Mysis relicta* and *Limnocalanus*. On the other hand they are fed upon extensively by the lake trout.

4. The outstanding item of food of the lake trout is ciscoes. In Lake Nipigon, where the operation of gill nets of $4\frac{1}{2}$ inch mesh only is permitted, the number of ciscoes taken is relatively small, and those which are taken are at present sent to the market as whitefish. In view of this fact and since the lake trout is of such great commercial importance, the feeding of the latter upon the ciscoes is not to be deplored. It has been a matter of some surprise that no whitefish have as yet been found in the lake trout stomachs, and if further investigation substantiates this condition, a very fortunate state of affairs will be shown to exist.

5. The food of the trout perch was evidently obtained in the river.

6. The importance of the nine-spined stickleback (*Pygosteus pungitius*) in the food of the yellow pike perch is interesting and is possibly correlated with the small numbers of minnows occurring in the lake.

7. The chief competitor of the lake trout is no doubt the ling, since it apparently feeds largely upon ciscoes. The

absence of fish of commercial value in its diet is important. It is interesting to note that five individuals had fed upon *Mysis relicta*. The amounts of the latter were so large as to preclude the possibility of their having been contained in cisco stomachs and, in fact, in three cases no other material could be detected.

8. The fish examined fall more or less definitely into the following groups as regards food:—(1) predaceous—lake trout, yellow pike perch, ling; (2) bottom feeders—sturgeon, northern sucker, common sucker, round whitefish, common whitefish; (3) open water plankton feeders—ciscoes; (4) shallow water plankton and insect feeders—young common suckers, minnows, young small mouth black bass, young yellow perch; (5) insect feeders—trout perch.

UNIVERSITY OF TORONTO STUDIES

Biological Series

No. 1: The gametophyte of Botrychium Virginianum, by E. C. Jeffrey ..... o.p.
No. 2: The anatomy of the Osmundaceae, by J. H. Faull. o.p.
No. 3: On the identification of Meckelian and mylohyoid grooves in the jaws of Mesozoic and recent mammalia, by B Arthur Bensley ..... o.p.
No. 4: The megaspore-membrane of the Gymnosperms, by R. B. Thomson 1.00
No. 5: The homologies of the stylar cusps in the upper molars of the Didelphyidae, by B. Arthur Bensley 0.50
No. 6: On polystely in roots of Orchidaceae, by J. H. White 0.50
No. 7: An early Anadidymus of a chick, by R. Ramsay Wright 0.25
No. 8: The habits and larval state of Plethrodon Erythronotus, by W. H. Piersol 0.50
No. 9: Spawn and larva of Ambystoma Jeffersonianum, by W. H. Piersol 0.25
No. 10: The colour changes of *octopus vulgaris* Lmk., by E. V. Cowdry 1.00
No. 11: The North American Dragonflies of the genus Aeshna, by E. M. Walker 2.00
No. 12: Ascidians from the coasts of Canada, by A. G. Huntsman 0.25
No 13: A contribution to the morphology and biology of insect galls, by A. Cosens 0.50
No. 14: Egg maturation, chromosomes, and spermatogenesis in Cyclops, by Robert Chambers 0.50
No. 15: A new cestode from *Amia Calva* L., by A. R. Cooper 1.00
No. 16: The egg-laying habits of *Plethodon Cinereus*, by W. H. Piersol 0.25
No. 17: An ecological study of the mayfly *Chirotenetes*, by W. A. Clemens 0.25
No. 18: The Isopoda of the Bay of Fundy, by N. A. Wallace 0.50
No. 19: An egg of *Struthiolithus Chersonensis* Brandt, by B. A. Bensley 0.50
No. 20: Publications of the Ontario Fisheries Research Laboratory, I-IX 1.50
No. 21: Publications of the Ontario Fisheries Research Laboratory, X (Glacial and Post-Glacial Lakes in Ontario), by A. P. Coleman 1.50
No. 22: Publications of the Ontario Fisheries Research Laboratory, XI-XVI 2.00